

GAME DAY PROMOTIONS AND TICKET SALES ANALYSIS:
THE DETROIT RED WINGS

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Section 1: Relevant Literature Review

Literature

The following literature review will identify the similarities and differences between four articles provided by the director of ticketing, including:

- 1) [“MLB attendance down 4 percent as 6 ballparks set lows.”](#) by Associated Press (AP) (2018)
- 2) [“Why MLB Attendance Dropped Below 70 Million For The First Time In 15 Years.”](#) by Brown (2018)
- 3) [“Baseball Saw a Million More Empty Seats. Does It Matter?”](#) by Allentuck and Draper (2019)
- 4) [“As lockout drags on, poll indicates MLB could be charting path to irrelevance.”](#) by Foster (2022)

Despite the focus on the MLB, several issues regarding factors influencing fan attendance and ticket sales can be translated to the NHL. The Key Takeaways section will discuss how such factors relate to the NHL and areas unique to league that should be considered in the marketing and attendance analysis.

Similarities

Both AP (2018) and Brown (2018) discuss the surprising drop in fan attendance for the 2018 MLB season, a low that had not been seen since 2003. Brown and AP agree on two elements that largely impacted the decline in attendance – bad weather and losing records. The MLB itself officially attributed the decrease to historically cold weather and justified this claim by noting that the percentage drop in attendance decreased following May 1. Brown and AP further support the claim citing that there were a record 54 postponements, the most since 1989, and 102 games played in temperatures under 50 degrees in April alone. While the provided evidence supports the weather claim, further research for aggregated weather totals for the MLB like total number of postponements per season, and total number of games played in

temperatures under 50 degrees has been futile. Without contextual data to compare the 2018 seasonal weather patterns, it's difficult to confirm that weather partially caused the decline.

Brown and AP also blamed wavering fan attendance on losing records. They both cited the Orioles, White Sox, and Royals losing more than 100 games in the 2018 season, and Brown noted that for the first time in the league's history, eight teams finished with 95 losses or more. Not to mention the other league first that season, there were more strikeouts than hits. With such lows, it's logical to see how fans may lose interest. However, both authors also pointed to teams like the Pirates and Rays who had winning seasons, but still saw a decline in fan attendance. Allentuck and Draper (2019) disprove the notion that reduced hits impacted attendance as the 2019 season saw a historically high homerun rate yet there was an additional decrease in fan attendance from 2018. Further, there has been much documentation on the "perennial loser", or team that is typically associated with losing but still maintains fan support and attendance (Rein, Shields, and Grossman 2015). Examples of well-known perennial losers are the Chicago Cubs and Toronto Maple Leafs, who demonstrate that records do not always determine attendance.

Foster (2022) and Allentuck and Draper (2019) provided suggestions as to how the league should work to improve attendance numbers and agreed that targeting a new, young generation of fans is key. Foster supported this by pointing out that the average age of an MLB fan/viewer has risen from 52 in 2000 to 57 in 2019. He also noted that lack of interest from the younger generation could be due to the characteristics of the game itself like the slow pace, lack of action, and extensive time commitment. Allentuck and Draper offer the same argument as to why the game may not be drawing a more youthful crowd, but also provide an additional reason – ticket prices. They provide support for this claim by discussing ballpark pass, a subscription that 18 of 30 MLB teams offered at the time writing, which allows fans to attend as many home

games as they want for a monthly fee, which is substantially lower than the cost of a single game ticket. The majority of purchasers of the ballpark pass were in their late-20s, likely the same age group that are used to paying subscription fees for other products like streaming services. With the success of the program, it's clear the pricing of traditional tickets is a barrier for younger fans.

There is one point that all authors agreed upon and that is baseball is losing the fight for attention in the ever-growing entertainment landscape. As evidence for this claim, Foster provides the results from a 2021 poll performed by Seton Hall University that reported 54 percent of the general population were not interested in the MLB. While poll results are not always exactly indicative of the attitudes of the nation, the Seton Hall University Sports Poll is quite credible as it has been performed for several years and thoroughly outlines the appropriateness of methodologies used (Ricciardelli 2021). With attendance numbers falling every year since 2018, it's undeniable that the MLB needs to rethink ticket sales and marketing. Regardless of what caused the decline, the top priority of the MLB should be adapting to meet the population's evolving needs. As Commissioner Manfred said, “All live entertainment is challenging because of changing habits” (AP 2018).

Differences

While Brown (2018) and AP (2018) agreed regarding the impact of weather and performance on the 2018 drop in attendance, they had differing opinions on additional causes. Brown states that the third and final reason the season had disappointing attendance numbers was because the Marlins and Blue Jays altered how they measured paid attendance. Brown cites the Marlin's different reporting procedure surrounding ticket sales as solely responsible for a quarter of the league's total 4% decline in attendance. However, he does not provide information about

how the Marlin's impact on the decline was calculated, so it's impossible to verify the truth behind the claim. Brown further elaborates that the Blue Jays changes stemmed from reducing the number of tickets sold on the secondary market but does not provide numeric evidence as to the impact on the seasonal decline.

On the other hand, AP attributes said decline to two additional factors, team rebuilds and roster age. AP did not provide further evidence that rebuilds impact attendance beyond a quote from Commissioner Manfred: "When teams rebuild, it always has an attendance effect." (2018) It was provided in the context of a broader discussion surrounding poor team performance, and thus implied that teams in a rebuild perform worse and in turn have lower attendance. Similarly, AP states that advance sales were down for teams that traded away or retired veterans and filled their roster with younger players in their stead, but again provided no numeric evidence for the claim. Neither Brown nor AP provided support for their additional reasons as to why fan attendance dropped in 2018, but their ideas should be considered nonetheless as they are plausible explanations of decline.

Allentuck and Draper (2019) suggest the driving force behind the trend of decreasing attendance is the "diminishing appeal" of season tickets and suites. They suggest fans are less reliant on season tickets to ensure access to postseason games or luxury suites as they are easily obtainable on the secondary market. Further, with 81 home games in a season, it's increasingly difficult for consumers to make such significant time commitments. They reference the success of the ballpark pass and the fact that teams, like the Giants, are demolishing in-stadium suites for more affordable seating as proof of their theory. Allentuck and Draper also suggest the increasingly valuable media rights deals that are brokered with television and streaming services

alter the way teams approach ticketing as they are less reliant on it as a revenue source. Where the previous goal of ticket sales was to maximize revenue, it's now just maximizing attendance.

The final differing proposal as to why fans are less engaged is presented by Foster (2022). Albeit a rare situation, Foster suggests that lockouts by management and player strikes have a detrimental effect on attracting new fans to the sport. He again cites the Seton Hall University Sports Poll where 44% of avid fans stated they would be less interested in the 2022 MLB season. He argues that any stoppage or delay in the season could mean turning away current fans and preventing the creation of the desperately needed, younger fanbase. After all, it's difficult to support a sport when there aren't any games being played. Each author presents their own unique take as to what's causing the downfall of fan attendance in the MLB, but they can all be considered from the perspective of the NHL.

Key Takeaways

When considering how the factors impacting fan attendance in the MLB translate to the NHL, a major difference between the leagues should be noted. The NHL is far more reliant on ticket sales than any other professional sports league with the largest portion of annual revenue coming from gate receipts (Jessiman 2019; Jones n.d.). Steps are being taken by the league to reduce their reliance on ticket sales like the 2021 signing of a 7-year media rights deal with Disney that's expected to bring in \$400 million annually (NHL.com 2023). Even with such efforts, the fact remains that ticket sales are vital to the financial health of the NHL and the individual teams within it. As such, the goal when considering ticketing and promotional strategies should be striking a balance between maximizing revenue and maximizing attendance. In determining what features to examine to help achieve this goal, consideration was given to the proposed causes of the drop in MLB attendance.

Within the similarities and differences sections, the authors provided several suggestions as to what elements impact fan attendance including: weather, team performance, ticket pricing, method of reporting attendance, characteristics of a team (in a rebuild, younger roster), ticket packaging, and lockouts. Due to ice hockey being played indoors, weather is typically not relevant to game attendance and thus is not considered in the analysis. There is no aggregated, publicly available information regarding method of reporting attendance, ticket packaging per game, or ticket pricing per game so they too were not considered in the analysis. As the league has not seen a lockout since the 2021-2013 season, consideration of lockout impact in this analysis would be irrelevant. The final two suggested factors – team performance and age – were considered in the analysis.

One benefit of performing a ticketing analysis is the ability to consider how the more logistical elements of the game like start time, day of week, and opponent, impact attendance. As such, additional factors not mentioned in the articles but pertinent to ticketing were also evaluated. One such example being the promotional schedule for the team's home games. All in all, the following factors are considered in the analysis:

- Team Performance
- Team Age
- Month
- Day of Week
- Start Time
- Opponent (Original Six, Division, Conference)
- Promotional Schedule

Section Two: Ticketing Analysis

Data Acquisition

To examine how the aforementioned factors impact ticket sales, acquisition of attendance, age, and promotional data was required. Attendance data for both the league as a

whole and each individual team was collected from hockey-reference.com. League-wide attendance data was scraped from a single web page and contained seven variables: team, arena name, arena capacity, games played, total attendance, average attendance, and percent capacity. Team attendance data was spread across 32 web pages, so web crawling and scraping was utilized once more. Team attendance data contained 16 variables: games played, date, start time, home/away, opponent, goals for, goals against, result, extra time, wins, losses, overtime losses, streak, game attendance, length of game, and notes. Age data was collected from hockey-reference.com by downloading a CSV file with two variables: team and average age. Finally, the promotional schedule from the 2022-2023 season was obtained via web scraping from the Red Wings “Promotions & Giveaways” page on nhl.com. Note that due to time constraints, impact of promotions will only be considered for the Red Wings. Once the relevant data was collected, several iterations of data cleaning, filtering, and manipulation were performed.

Data Cleaning, Filtering, and Manipulation

Upon reading in each team’s attendance data, it was concatenated into a single data set. During the web scraping process, a home team and abbreviation variable was added to the data for each respective team. Next, variable names were cleaned using the “janitor” package in R. Three additional variables were created that classified each team’s opponent by division, conference, and if they are in the “original six.” The home/away variable entries were altered so that each game was classified as one of two options, “home” or “away”. Those games classified as “away” were then dropped from the data set so each team home games were only being considered. Two more variables – weekday and month – were created by manipulating the original date variable. The start time variable was manipulated to convert start times into one of three categories: afternoon, evening, and night. Time frames representing these groups were 12–

5 PM, 5–7 PM, and 7-10:30 PM, respectively. Similarly, the streak variable, which is the teams streak prior to each game, was broken down into six categories: lose 5+, lose 3-5, lose 1-2, win 1-2, win 3-5, and win 5+.

Examination of the capacity variable for the league as a whole led to the discovery that certain team's average attendance was more than their arena capacity. As this is indicative of incorrect capacities for respective arenas, they were not used for the analysis. Instead, a capacity variable for each team was created by extracting the maximum attendance of all games. Several resulting capacities were fact checked online and found to be accurate and thus were used in the analysis. The assumed arena capacities used in this analysis can be found in Appendix A. From the capacity variable, a percent capacity variable was created by dividing game attendance by arena capacity. The final additional variable to be added to the individual team's data set was average age, which was done by merging the age data based on team name.

Data exploration of the notes variable revealed four games that were not played at either team's home ice. They included two consecutive matchups between the Blue Jackets and Avalanche at Nokia Arena (Tampere, Finland), a matchup between the Capitals and Hurricanes at Carter-Finley Stadium (Raleigh, NC), and a matchup between the Penguins and Bruins at Fenway Park (Boston, MA). As these games were not played at home arenas there dropped from the data set. Once the aforementioned games were dropped, the data set was ready for analysis with a total of 1,308 rows and 28 variables.

Prior to analysis, the promotional data was cleaned. This required extracting dates from scraped data, compiling them into a list, parsing through each date, attaching the relevant year, and converting to the date class. A subset of the individual team data set was created by filtering for Red Wings games only. The Red Wings data set was then merged with the promotional data

to create a promotion variable that indicated if a game was included in the promotional schedule. The Red Wings data set was then ready for analysis and consisted of 41 rows and 29 variables.

League-Wide Ticket Sales

In looking to understand how various factors impact ticket sales, the metric which is used to measure ticket sales must be considered. One option is total fans in attendance, which has the benefit of quantifying the exact number of tickets sold. However, a major drawback of using fans in attendance is its inefficiency in comparing different teams. As each team's home ice location has a unique maximum capacity, comparing raw attendance numbers will not portray an accurate picture of the team's ability to sell out games. An alternative metric is percent capacity. This is calculated by dividing game attendance by arena capacity and multiplying by one hundred. Percent capacity standardizes ticket sales so that they can be compared equally amongst teams. For this reason, percent capacity was used for the league-wide analysis of ticket sales. One notable drawback of percent capacity can be observed in Figure 1.

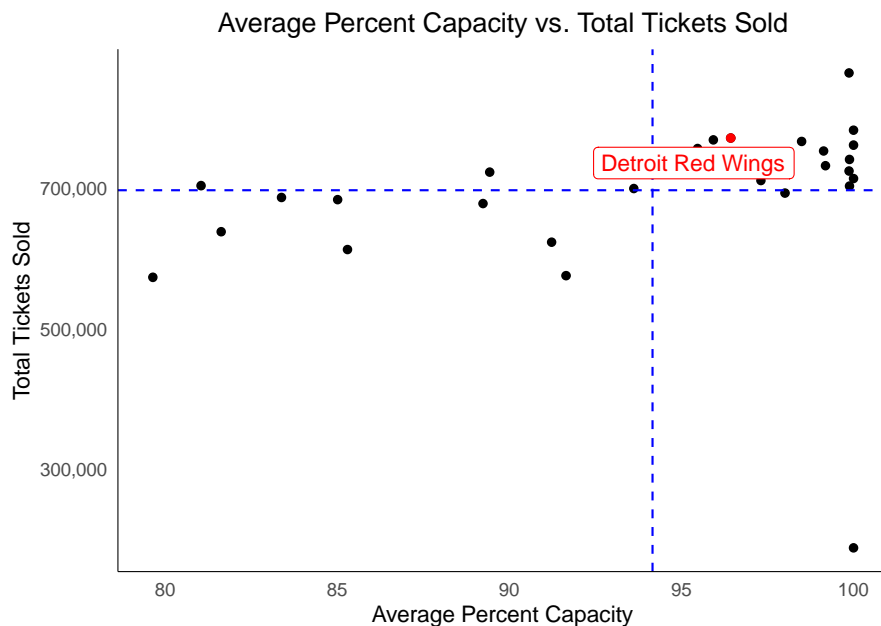


Figure 1. Average percent capacity vs total tickets sold across all teams in the 2022-2023 NHL season.

When examining Figure 1, there is an obvious outlier in total tickets sold, selling under half the tickets of the next closest team. Said outlier is the Arizona Coyotes at their current home ice, Mullet Arena, with a capacity of only 4,600. Due to the considerably smaller number of tickets to sell to home games, the Coyotes have an average percent capacity of 100%. It could be argued that the Coyotes 100% capacity is not as significant as it would be for other teams. Such drawbacks of percent capacity should be taken into consideration when evaluating the results of the league-wide analysis.

The first factors to be evaluated for impact on fan attendance across the league were month, day of week, and start time of home games. The resulting box plot for each factor can be found in Figures 2-4.

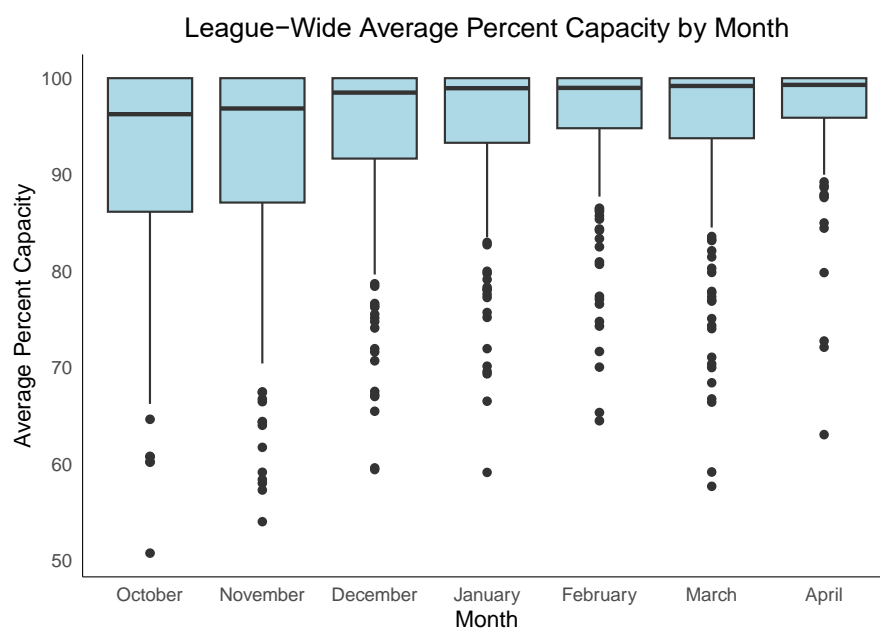


Figure 2. Average percent capacity by month for all teams in the 2022-2023 NHL season.

When interpreting boxplots, the most important aspects to draw your attention to are the solid black line in the middle of the box, the size of the box, and the additional points outside of the box. The black line represents the median, or middle value, observations, the size of the box represents the range that the majority of the values fall in, and the additional points are outliers.

For example, in Figure 2, the percent capacity values for all games in October have a median value of approximately 97%, the range that the majority of values fall within is approximately 87%-100%, and there are four outlier values. Comparing each of these aspects from month to month can provide insight into attendance trends.

From Figure 2, it can be observed that the median attendance grows as the season progresses. This makes sense as earlier games aren't as crucial compared to those later in the season that could clinch a playoff spot.

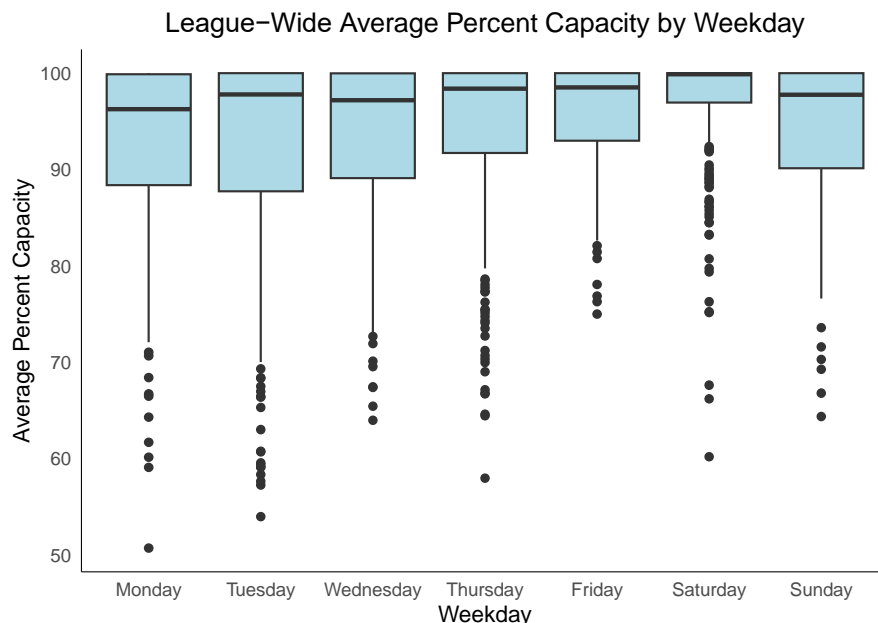


Figure 3. Average percent capacity by day of week for all teams in the 2022-2023 NHL season.

The key takeaways from Figure 3 are that Saturday games have the highest median percent capacity of approximately 99% and Monday games have the lowest median percent capacity of approximately 96%. Interestingly, Sunday games have a lower median percent capacity than Thursday or Friday games.

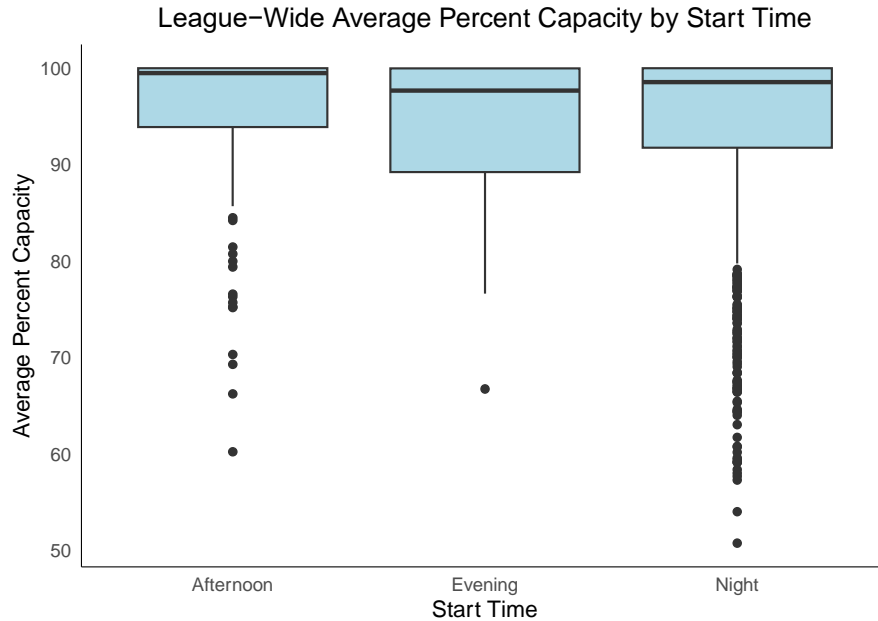


Figure 4. Average percent capacity by start time for all teams in the 2022-2023 NHL season.

Note that in Figure 4 afternoon games refer to those that start between 12 and 5 pm, evening refers to between 5 and 7 pm, and night refers to between 7 and 10:30 pm. Afternoon games maintain the highest median percent capacity which is unsurprising given afternoon games are typically played on Saturday or Sunday. As we know from Figure 3, Saturday games are likely to be near 100% capacity. Another notable observation is that evening games have the lowest median percent capacity, but the least outliers. This suggests that while the attendance may be the lowest for evening games, the attendance was most consistent across the three time slots.

The next two factors that were considered have to do with characteristics of the home team – performance and average age. The resulting boxplots can be found in Figures 5 and 6.

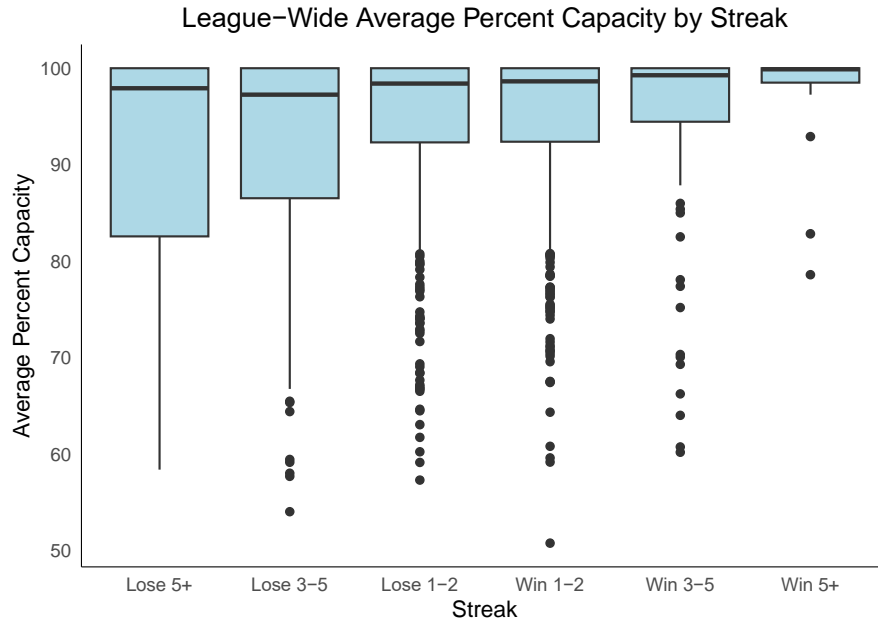


Figure 5. Average percent capacity by recent performance for all teams in the 2022-2023 NHL season.

In Figure 5, streak represents the teams winning or losing streak prior to the start of a game. It can be observed that losing or winning 1-2 games makes little difference in median percent capacity, while losing or winning more than 1-2 games does alter median percent capacity. Such results split the difference between those observed in the MLB. As Brown (2018) AP (2018) noted, winning more games leads to higher attendance. The theory of “perennial losers” also appears to rein true here as those who lost 5 or more games had a higher median percent capacity than those who lost only 3-5.

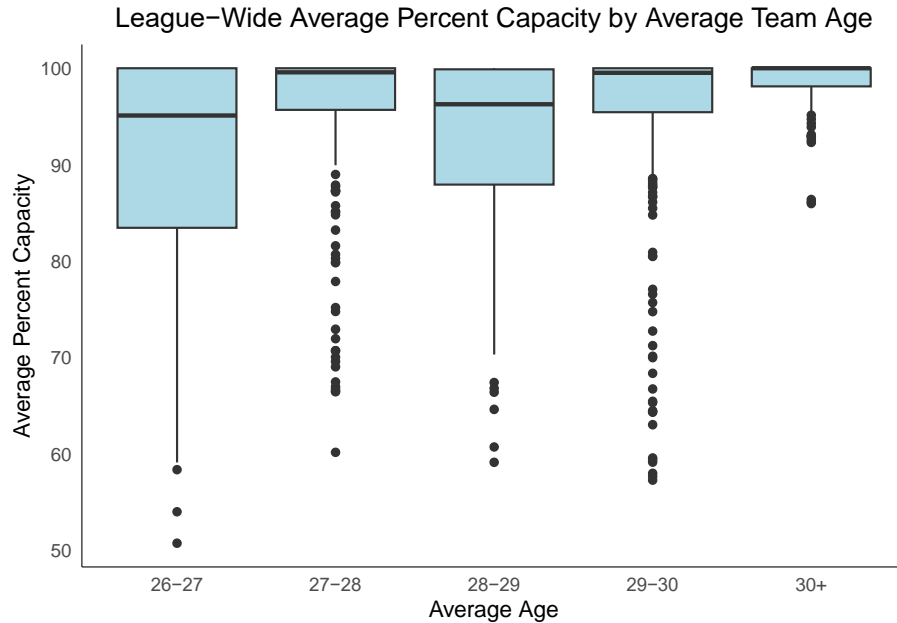


Figure 6. Average percent capacity by average home team age for all teams in the 2022-2023 NHL season.

At first glance of Figure 6, it's clear there is much variation in attendance based on team age. It appears that teams with an average age of 27-27, 29-30, or 30+ have the highest median percent capacity. While these observations are true, it's important to consider the underlying data. For example, only two teams, the Washington Capitals and Pittsburgh Penguins, had an average age greater than 30 and their average percent capacities were 100% and 97%, respectively. With such highest average percent capacities and only 2 observations, the data is quite skewed for that age category. For this reason, the trends observed in Figure 6 should be considered carefully and not weighed too heavily in ticket sale considerations.

The final elements of a game to be considered for the league-wide ticket analysis were based opponent. The three opponent considerations were if the team is included in the "Original Six", their conference, and their division. Results can be found in Figures 7-9.

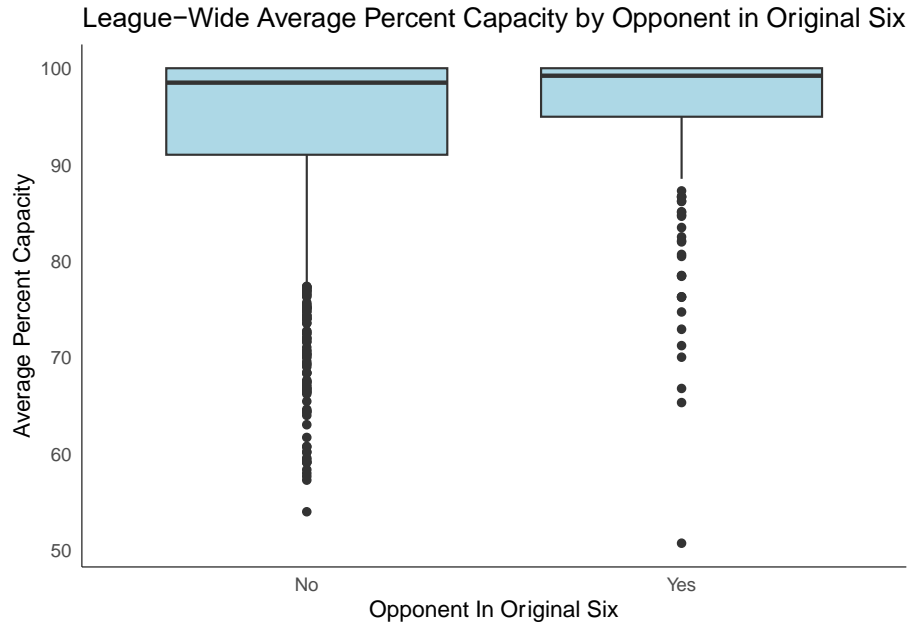


Figure 7. Average percent capacity by opponent’s inclusion in the “Original Six” for all teams in the 2022-2023 NHL season.

Figure 7 demonstrates that the median percent capacity of games where the opponent is included in the “Original Six” is slightly higher than those where the opponent is not. Games including an “Original Six” team also have more consistent attendance numbers as the range is nearly half that for games without an “Original Six” opponent.

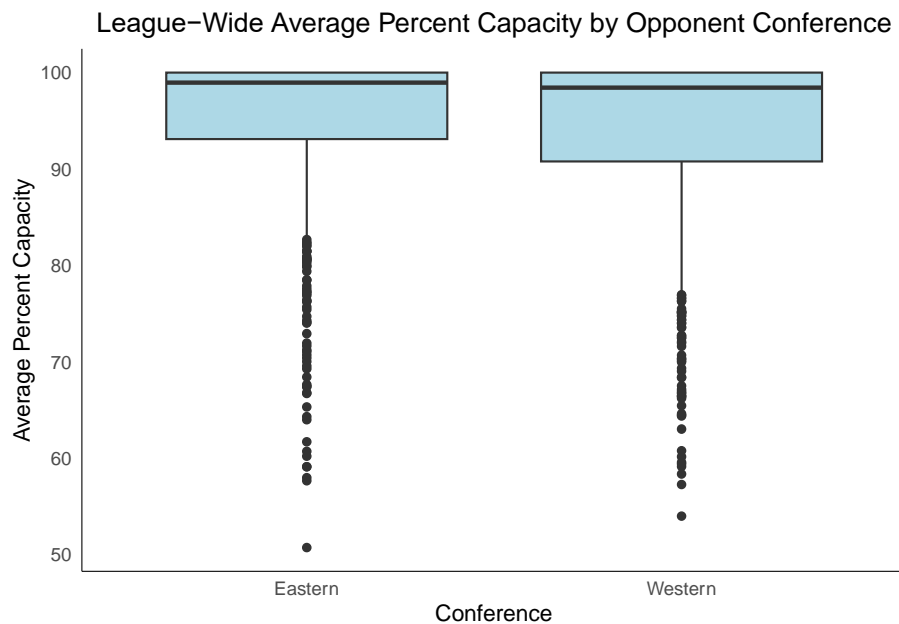


Figure 8. Average percent capacity by opponent's conference for all teams in the 2022-2023 NHL season.

In Figure 8, Eastern Conference opponents have a higher median percent capacity than Western Conference Opponents. Given the results from Figure 7, it makes sense that we also observe higher attendance for the Eastern Conference as five of the six original team are included.

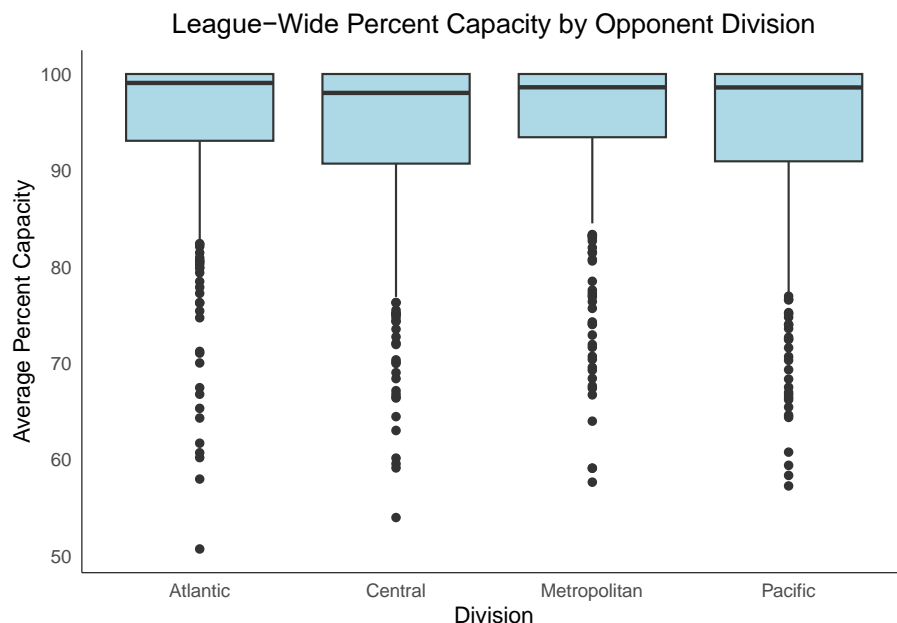


Figure 9. Average percent capacity by opponent's division for all teams in the 2022-2023 NHL season.

The results from Figure 9 agree with those from Figures 7 and 8 as the divisions within Eastern Conference – Atlantic and Metropolitan – have the highest median percent capacities. Interestingly, the division with the only “Original Six” team in the Western Conference – the Central - has the lower median percent capacity compared to its Pacific counterpart. Ultimately Figures 7-9 agree that opponent has an impact on percent capacity.

Upon completion of visualizing how relevant factors impact attendance, a linear regression was performed to quantify the statistical relationships. However, an issue with this method was immediately encountered. As different teams typically draw different attendance

levels, there was a suspicion that the team variable would have a strong impact on percent capacity. To test this, two linear regressions were performed: one with all relevant factors plus team and one with all relevant factors only. The regression was run on two data sets, a training set consisting of 2/3 of the entire data set and a test data set consisting of the other 1/3 of the entire data set. The first regression resulted in an adjusted r-squared value of 0.59 on the training set and 0.52 on the test data set. These values mean that the variables included in this regression, all relevant factors plus team, explained 59% and 52% of the variance of the test and training data sets, respectively. Both results are a respectable amount of variance explained.

When the regression was re-run without the team variable, the resulting adjusted r-squared values for the training and test data sets were 0.18 and 0.11, or 18% and 11%. The massive decrease in explained variance upon removing the team variable suggests it was extremely important to predicting percent capacity, far more than the other relevant factors combined. Thus, using the results of this linear regression to quantify relationships between the other relevant factors and percent capacity would be futile. Fortunately, running the same type of regression on the Red Wings attendance data alone will prove more successful as different teams are not being compared.

Red Wings Ticket Sales

Referring back to Figure 1, the horizontal blue dashed line represents the league average for total tickets sold and the vertical blue line represents the league average for percent capacity. As the Detroit Red Wings are sitting above both lines, we are in a good position when it comes to tickets sales compared to the rest of the league. To analyze Red Wings ticket sales, raw attendance data was used rather than percent capacity as each game being compared has the same maximum capacity. All the same visualizations were created for the Red Wings attendance

data as the league but two; First, age was not considered as this remains roughly the same for a team throughout the year. The second change comes from the creation of a promotional visualization comparing home games on the promotional schedule versus those that are not.

As many of the Red Wings visualizations mirrored the trends observed in the league-wide visualizations, they can be found in Appendix B. There were only two differences observed between the two data sets. The first was that for the Red Wings, an opponent in the “Original Six” had a lower median attendance than those not in the “Original Six”. The second difference was that the Pacific Division had the second highest median attendance rather than the Metropolitan. Otherwise, the same trends were observed for the rest of the factors with slightly more variation, which is to be expected due to the smaller sample size.

The additional visualization of the impact of the promotional schedule can be found in Figure 10.

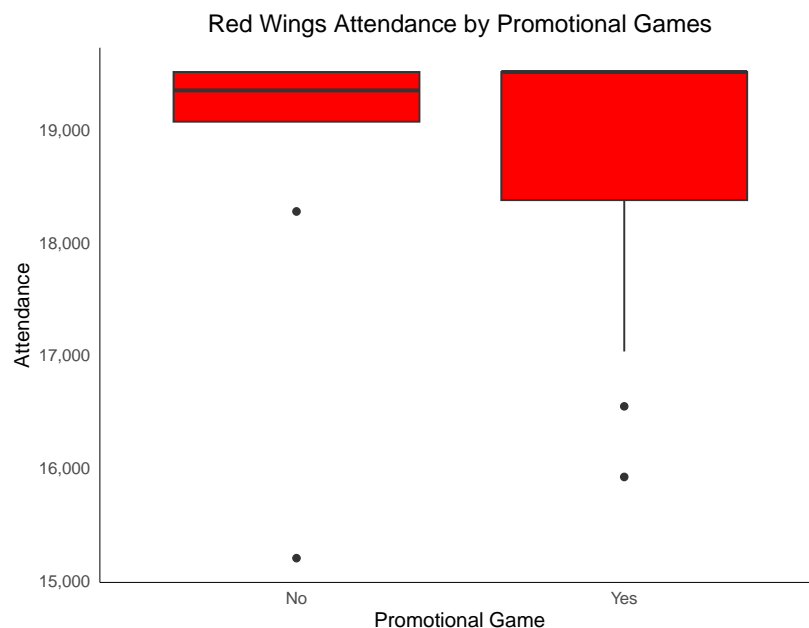


Figure 10. Detroit Red Wings fan attendance by inclusion in promotional schedule for the 2022-2023 season.

Figure 10 confirms the logical expectation that home games on the promotional schedule have a higher median attendance than those not on the promotional schedule. Those in the promotional schedule also had a greater range. It should be noted, however, that of the 41 home games, only 9 were not included in the promotional schedule.

As mentioned earlier, a linear regression examining the relationship between relevant factors and fan attendance was performed. The same procedure was followed as the league-wide regressions with a training-test split of the data of two thirds to one third. The resulting adjusted r-squared values for the training and test data were 0.39 and 0.16, or 39% and 16%, respectively. The predictive power of the model can be seen in Figure 11.

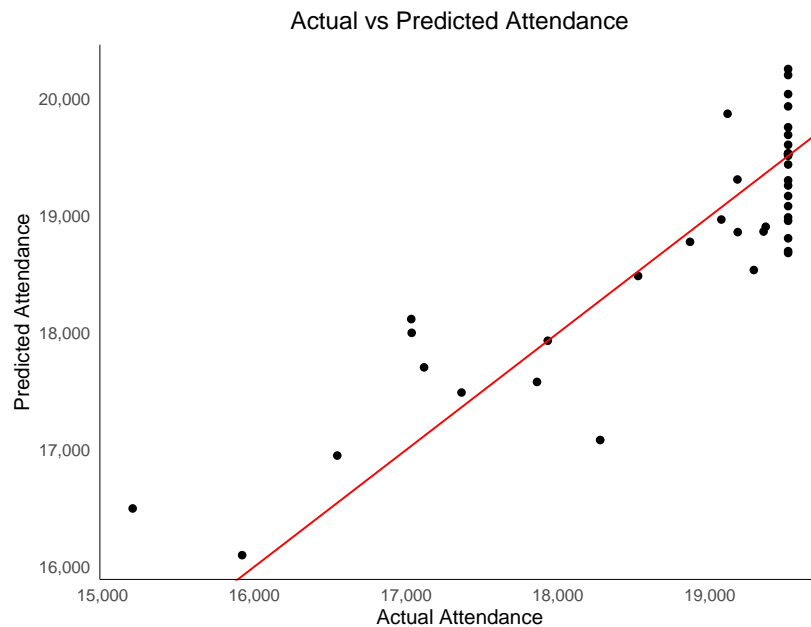


Figure 11. Actual versus predicted attendance for all games in the 2022-2023 Red Wings season.

The red line in Figure 11 represents the center point between the actual and predicted attendance axes. Ideally, the points would be plotted closely along this line. However, the model appears to be struggling with predictive capability, especially when predicting games that were sold out, as can be seen in the cluster of points along the right edge of the graph. It's unsurprising

that the model is not performing especially well given it only had 41 observations to train on. In order to improve its predictive capability, additional seasons of data will need to be passed through it.

Despite the lacking predictive performance, the model was able to identify coefficients related to each variable as can be seen in Table 1.

Table 1. Coefficients produced by linear regression model on Red Wings 2022-2023 attendance data.

Variable	Coefficient
Constant	15237
Opponent in "Original Six"	698
Western Conference	848
Central Division	-720
Metropolitan Division	584
Tuesday	1116
Wednesday	1401
Thursday	1192
Friday	2456
Saturday	1706
Sunday	1561
November	1055
December	2398
January	1989
February	1744
March	1430
April	2466
Evening	-304
Night	-171
Lose 1-2	264
Win 1-2	670
Win 3-5	1419
Promotional Game	-81

Each variable's coefficient in Table 1 is the model's prediction of impact on attendance, or how many fans a certain variable will add or detract from the total. However, only the highlighted variables were found to be significant. This means that while non-highlighted

variables have estimates, that should not be taken as truly indicative of the factor's impact on attendance. Thus, with the current model, we can only consider the resulting coefficients of the day of week (only Tuesday through Saturday) and month (only December through April) to be indicative of impact on attendance. With these factors in mind, we can strategically approach a ticket pricing strategy based on fan attendance patterns observed in the model.

Section Three: The Dynamic Pricing Model

What is the Dynamic Pricing Model?

Dynamic pricing is arguably the most popular ticket pricing strategy in modern business. With its origins dating back to the airline industry in the 1980s, dynamic pricing has spread to several industries like hospitality, entertainment, transportation, and e-commerce (Suwada 2022). Sometimes referred to as demand or time-based pricing, is a pricing model that allows for the constant fluctuation of prices in response to market conditions (Suwada 2022). What those conditions are and how much of an impact they have on price is determined by industry.

The first instance of dynamic ticket pricing in the NHL was when the Dallas Stars announced they would be implementing it for their upper level in the 2009-2010 seasons (Dallas Stars Staff 2009). Since then, the majority of teams have taken up the strategy with the most recent announcement coming from the Buffalo Sabres in the 2016-2017 season (Staff Writer 2016). In that announcement the Sabres detailed that their games were categorized based on opponent, time of year, day of week, rivalries, and star players. Dynamic pricing models in general also factor in customer demand and secondary market ticket prices in their calculations. While the dynamic pricing model has been widely accepted by teams across the league, it has both benefits and drawbacks.

Benefits

The dynamic pricing model provides many benefits for NHL teams such as increased profits, increased flexibility, and decreased unused inventory. The primary and most-appealing benefit of the dynamic pricing model is the increased ticket revenues that come with it. A case study of the San Francisco Giants saw their overall revenue increase by 7% just one year after implementing a dynamic pricing strategy (Schrute 2018). The increased flexibility of the strategy comes from having the choice of variable to optimize. For example, should a team be more concerned with filling seats than profits, they can elect to maximize attendance with their pricing strategy instead. The final benefit is a decreased in unused ticket inventory. Rather than leave prices static and risk having empty seats at the game, an organization can opt to lower tickets to an attractive price that draws in last-minute purchasers. This strategy not only fills potentially unused seats, but also brings in merchandise, parking, and concession revenues that wouldn't have been available had they not lowered the ticket price. With the dynamic pricing model's many benefits also comes some notable drawbacks.

Drawbacks

The two major cons of employing a dynamic pricing model are the potential to upset customers by altering prices and the model's reliance on data accuracy and accessibility. The foremost of the two is the customer response to price changes. It's logical that it could be frustrating for a fan who has already purchased a ticket to see that the same ticket they purchased is now half the price. To safeguard against this issue, teams employ hard limits for the price a ticket can exceed or fall below, and they guarantee that tickets never fall below season ticket prices (Staff Writer 2016). The other risk of utilizing this strategy is its reliance on accurate data about market conditions as well as an easily accessible data infrastructure. Should the model

receive inaccurate data, it can easily recommend prices that will lead to a loss. Similarly, should the data infrastructure system fail to get data to the model, it will also fail to recommend optimal prices. To prevent this from occurring, teams need to ensure they have the technical fortitude in-house or outsource pricing to a company that does. The drawbacks of the model are notable and require careful planning but do not outweigh the numerous benefits.

Relevant Factors

For the Detroit Red Wing in particular, the results of the linear regression model should be used to inform the relevant factors used in the dynamic pricing model. In doing so, only those factors found to have significant coefficients - weekday and month – should be considered. Using these factors, games can be classified into different tiers that have different baseline pricing. For example, games in March or games on Tuesdays, those that are predicted to contribute the lowest number of fans to attendance should be placed in the lowest tier with the lowest prices. This way fans are incentivized by lower ticket prices to attend the least popular games. A detailed breakdown of the recommended tiers can be found in the following “Recommendations” section.

Section Four: Recommendations, Limitations, and Future Research

Recommendations

The recommended tier system and associated games can be seen in Table 2.

Table 2. Recommended tier system for Red Wings.

Tier	Month	Weekday
I	April	Friday
II	December	Saturday
III	January, February	Wednesday
IV	March	Tuesday, Thursday

The most sought-after games are included in the first tier in descending order to the fourth tier. As each step down in tier represents less consumer demand, I'd recommend a 5% drop in baseline price, starting the tier I prices well above season ticket prices to ensure that a cumulative 20% drop in price will not fall below season ticket prices. While our model is not performing at the highest level yet, thus preventing us from including more detailed variables like opponent, performance, promotion, or start time, signs are positive moving forward as other teams have also been cited to use day of week and time of year to set dynamic pricing. Similarly, the tier system has been adopted and proven successful by teams like the Buffalo Sabres (Staff Writer 2016). As advancing our pricing recommendations is heavily dependent on model success, identifying the limitations and areas for future improvement is essential.

Limitations

There were several limitations of the analysis performed in this report including inaccurate data, poor model performance, and time constraints. As mentioned in the "Data Cleaning, Filtering, and Manipulation" section, the capacity data for each respective team's arena was found to be inaccurate. This inaccuracy was able to be remedied by imputing maximum attendance from individual game data, but the question remains if game attendance totals were inaccurate as well. Such an issue can only be resolved by acquiring verified attendance and capacity data from each team.

The linear regression model's poor predictive performance severely inhibited the analysis. Without strong predictive power, the model is unable to produce significant variable coefficients which leaves us with little to work upon in terms of pricing strategy. Again, the suspected cause of the model's poor performance is the small sample size on which it was trained. This ties into the issue of time constraints as deadlines prevented the time-consuming

process of scraping additional seasons worth of data to train the model on. Time also played a role in the fact that only the promotional schedule of the Red Wings was considered instead of all teams in the league. Fortunately, many of these limitations can be addressed in future research.

Future Research

The primary goal of future research will be improving the predictive capability of the model. To do so, several steps will be taken. First, additional seasons of attendance data will be acquired. This will require working with the Ticket Sales and Service team to obtain internally acquired data for the Red Wings. Outreach to other teams in the league will also be attempted with the hopes of obtaining accurate ticket sales information. Should they be unwilling to share that information, the same publicly available source, hockey-reference.com will be used again.

The second step to improve the predictive capability of the model will be to test different model types. Again, due to time constraints, only a classic linear regression model was used. However, there are many regularization techniques that can be employed on linear models such as Lasso, Ridge, and Elastic Net regressions. These techniques can further improve the predictive power of linear regression by preventing over-fitting on the training data set (Swamy 2018). No additional resources besides time would be required as the necessary packages are already loaded in the program being utilized for the analysis.

The final step will be the collection of promotional data for all teams in the league. To do so, each team's promotional schedule page on NHL.com will need to be scraped. The challenging aspect of this task will be parsing through the scraped data to obtain dates of the promotional events as well as details of the event. Ideally, events such as giveaways, celebration nights, and raffles will be categorized for each game. While the actual collection of other team's

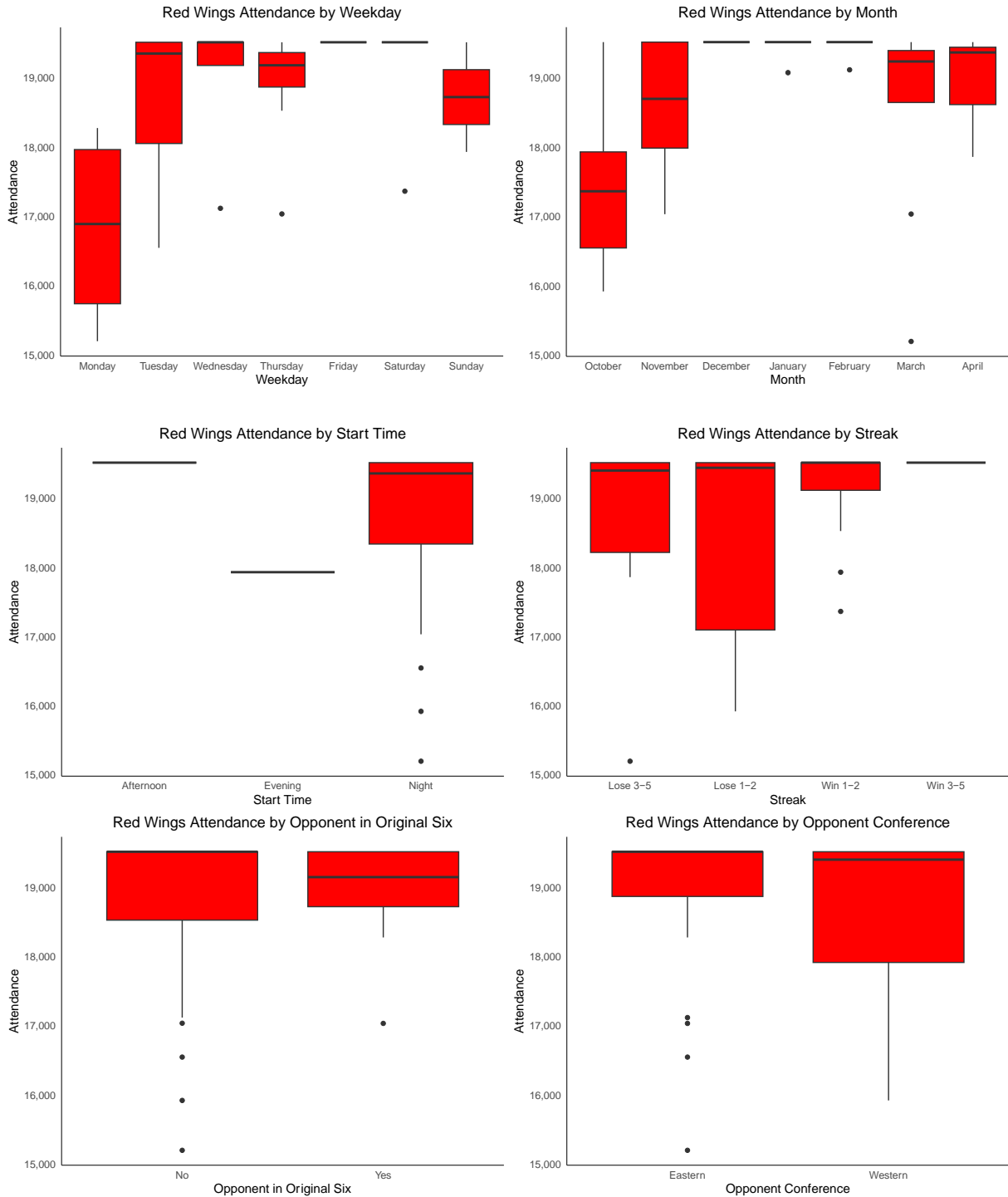
promotional data will not improve the Red Wings model itself, the further breakdown of promotional data will allow for new variables to be added and thus, new coefficients calculated. Again, no additional resources will be required to complete this step of the process.

The combination of additional season data, improved regression techniques, and detailed promotional data will be a sure-fire way to improve prediction capability of the model. A more advanced model means more accurate insights for the organization to gain regarding ticket pricing strategy.

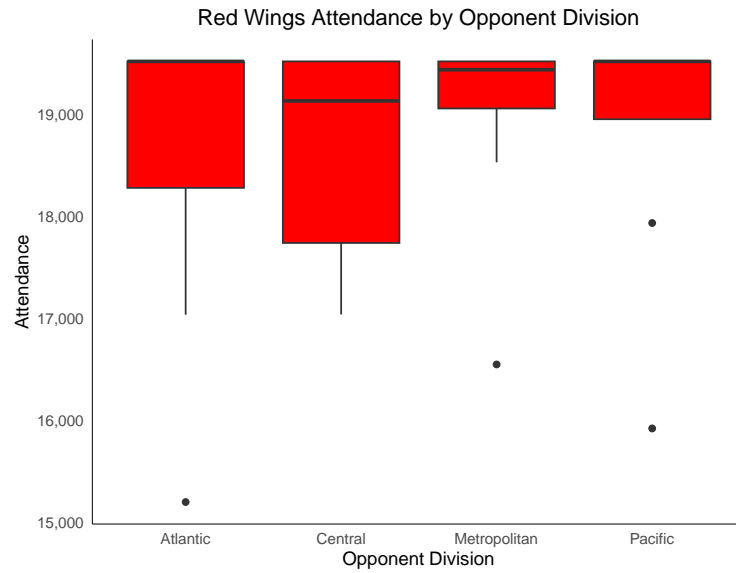
Appendix A: Assumed Home Ice Capacities

Team	Home Ice Location	Capacity
Anaheim Ducks	Honda Center	17,530
Arizona Coyotes	Mullett Arena	4,600
Boston Bruins	TD Garden	17,850
Buffalo Sabres	KeyBank Center	19,070
Calgary Flames	Scotiabank Saddledome	19,289
Carolina Hurricanes	PNC Arena	18,965
Chicago Blackhawks	United Center	21,182
Colorado Avalanche	Ball Arena	18,143
Columbus Blue Jackets	Nationwide Arena	19,004
Dallas Stars	American Airlines Center	18,532
Detroit Red Wings	Little Caesars Arena	19,515
Edmonton Oilers	Rogers Place	18,347
Florida Panthers	FLA Live Arena	19,623
Los Angeles Kings	Crypto.com Arena	18,230
Minnesota Wild	Xcel Energy Center	19,329
Montreal Canadiens	Bell Centre	21,105
Nashville Predators	Bridgestone Arena	17,823
New Jersey Devils	Prudential Center	16,669
New York Islanders	UBS Arena	17,255
New York Rangers	Madison Square Garden (IV)	18,006
Ottawa Senators	Canadian Tire Centre	20,097
Philadelphia Flyers	Wells Fargo Center	19,719
Pittsburgh Penguins	PPG Paints Arena	18,456
San Jose Sharks	SAP Center at San Jose	17,562
Seattle Kraken	Climate Pledge Arena	17,171
St. Louis Blues	Enterprise Center	18,096
Tampa Bay Lightning	Amalie Arena	19,092
Toronto Maple Leafs	Scotiabank Arena	19,549
Vancouver Canucks	Rogers Arena	18,988
Vegas Golden Knights	T-Mobile Arena	18,467
Washington Capitals	Capital One Arena	18,573
Winnipeg Jets	Canada Life Centre	15,325

Appendix B: Red Wings Factor Visualizations



Appendix B: Red Wings Factor Visualizations (Continued)



References

- Allentuck, Danielle and Kevin Draper. 2019. "Baseball Saw a Million More Empty Seats. Does It Matter?" New York Times (Online), September 29, 2019. <https://www.nytimes.com/2019/09/29/sports/baseball/mlb-attendance.html>.
- Associated Press (AP). 2018. "MLB attendance down 4 percent as 6 ballparks set lows." USA Today, October 2, 2018. <https://www.usatoday.com/story/sports/mlb/2018/10/02/mlb-attendance-down-4-percent-as-6-ballparks-set-lows/38023565/>.
- Brown, Maury. 2018. "Why MLB Attendance Dropped Below 70 Million For The First Time In 15 Years." Forbes, October 3, 2018. <https://www.forbes.com/sites/maurybrown/2018/10/03/how-mlb-attendance-dropped-below-70-million-for-first-time-in-15-years/?sh=52c9818361bf>.
- Dallas Stars Staff. 2009. "Stars Unveil Dynamic Ticket Pricing." NHL.com, September 9, 2009. <https://www.nhl.com/stars/news/stars-unveil-dynamic-ticket-pricing/c-497968>.
- Foster, Jason. 2022. "As lockout drags on, poll indicates MLB could be charting path to irrelevance." The Sporting News, January 6, 2022. <https://www.sportingnews.com/us/mlb/news/as-lockout-drags-on-poll-indicates-mlb-could-be-charting-path-to-irrelevance/1qbmfwrcjfdsr16izao285afnw>.
- Jessiman, Earl. 2019. "Dynamic Pricing Improves NHL Teams' Bottom Lines." The Hockey Writers, January 12, 2019. <https://thehockeywriters.com/dynamic-pricing-improves-nhl-teams-bottom-lines/#:~:text=NHL%20teams%20are%20following%20the,%2C%20a%20dynamic%20pricing%20system%20%E2%80%9C%E2%80%A6>.
- Jones, Wayne. n.d. "What is the yearly revenue of the NHL? (plus, where it comes from)." Hockey Answered. Accessed May 13, 2023. <https://hockeyanswered.com/what-is-the-yearly-revenue-of-the-nhl/#:~:text=What%20is%20the%20yearly%20revenue%20for%20the%20NHL%3F,splitt%20these%20revenues%2050%2F50>.
- Miller, Thomas. 2015. *Sports analytics and data science: Winning the game with methods and models*. New York: Pearson.
- NHL.com. 2023. "NHL Games on ABC, ESPN+, TNT experiencing significant ratings increases." NHL.com News, March 15 2023. <https://www.nhl.com/news/nhl-games-on-abc-espn-tnt-experiencing-significant-ratings-increases/c-342278934>.
- Rein, Irving, Ben Shields, and Adam Grossman. 2015. *The Sports Strategist : Developing Leaders for a High-Performance Industry*. New York: Oxford University Press.

- Ricciardelli, Michael. 2021. "A Warning to the MLB: 30% of Fans (and 44% of Avid Fans) Say 'Less Interest' When Games Resume; Fans Divided on Baseball Rule Changes, but by 6 to 1 Avid Fans Say Both Leagues Should Have DH, By 2 to 1 Fans Say Extend Wild Card to Series; Support Shorter Season." The Seton Hall Sports Poll, December 15, 2021. <http://blogs.shu.edu/sportspoll/2021/12/15/a-warning-to-mlb-30-of-fans-and-44-of-avid-fans-say-less-interest-when-games-resume-fans-divided-on-baseball-rule-changes-but-by-6-to-1-avid-fans-say-both-leagues-should-have-d/>.
- Schrute, Dwight K. 2018. "Get Em While They're Hot: Dynamic Ticket Pricing in Major League Baseball." Technology and Operations Management: MBA Student Perspectives, November 13, 2018. <https://d3.harvard.edu/platform-rctom/submission/get-em-while-theyre-hot-dynamic-ticket-pricing-in-major-league-baseball/>.
- Staff Writer (Buffalo Sabres). 2016. "Sabres Announce New Dynamic Ticket Pricing Structure." NHL.com, <https://www.nhl.com/sabres/news/sabres-announce-new-dynamic-ticket-pricing-structure/c-891524>.
- Suwada, Krzysztof. 2022. "The Pros and Cons of Dynamic Pricing: What You Need to Know." Nexocode, August 9, 2022. <https://nexocode.com/blog/posts/pros-and-cons-of-dynamic-pricing/>.
- Swamy, Vijay. 2018. "Lasso Versus Ridge Versus Elastic Net." Medium, October 15, 2018. <https://medium.com/@vijay.swamy1/lasso-versus-ridge-versus-elastic-net-1d57cfc64b58>.