Substitution Effect in Sport Event Attendance

Completed Research

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Abstract

In this paper, we intend to estimate the impact that two professional sports leagues, the National Hockey League (NHL) and the National Basketball Association (NBA), have on the attendance of Major League Baseball (MLB) games over an 11-year span when there are schedule conflicts. Overall, we observe that NHL and NBA games that have schedule conflicts with MLB games more significantly negatively impact the attendance on MLB games during the weekdays (in particular, Thursday and Wednesday) than on MLB games during the weekend. We also observe that MLB teams in high standings suffer less from negative substitution effects than MLB teams in low standings in the division. In particular, when MLB teams are in a losing streak, spectators show their deepest disappointments in their teams and avoid to attend MLB games in stadium when there are schedule conflicts.

Keywords

Substitution effect, sport economics, sport analytics, sport event attendance.

Introduction

Identifying factors and calibrating models to predict the attendance demand for various sport events have garnered great attention from regulators, executives, and administrators of professional sports leagues as well as academic researchers. In this paper, we focus on the attendance data sets of the professional Major League Baseball (MLB) after considering its economic size (i.e., the overall revenue of the MLB league was estimated to be $9.46 billion in 2017), which makes MLB franchises the third-most worth professional sports league in USA (Statista 2019). Ultimately, it is our goal to help decision makers of MLB teams and MLB league by identifying and visualizing factors that impact the attendance demand on MLB games so that executives and administrators can tune marketing campaigns to optimize the revenue of teams and league.

We, in particular, intend to estimate and visualize the impact of substitute sport events on the attendance of MLB games. To this end, we first briefly review previous studies on sport economics that have calibrated various models to either estimate the attendance or identify factors that affect the attendance of sport events. Our consideration of substitute sport events scheduled on the same game day and near locations that MLB events occur makes our research different from previous studies. Note that most of previous studies identify external factors such as weather, the income per capita of the home team's and the visiting team's region, geographical distance between the cities where the teams are located. We also briefly review representative deep learning algorithms, Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs), for the prediction task of attendance demand on MLB games. Next, we collect and process the attendance data sets of MLB games between 2008 and 2018 through a data scraping program created with Python. We also scrape schedules of the National Hockey League (NHL) and the National Basketball Association (NBA) over the same period. Then we estimate and visualize the substitution effects of NHL and NBA games on the attendance of MLB games. Finally, we conclude our paper by suggesting several future research directions.

Literature Review on Sport Economics

According to Forbes' estimate, the overall revenue of the MLB league was $9.46 billion in 2017 (an average of $315.33 million per team), which makes MLB franchises the third-most worth on average after the

National Football League (NFL) and the National Basketball Association (NBA) (Statista 2019). In addition, the league-wide revenue of MLB franchises has almost doubled over the past ten years Therefore, it is very critical for industry decision makers (e.g., regulators, executives, and administrators) and researchers in sports economics and marketing community to calibrate models to either estimate the attendance demand or identify factors that affect the attendance of MLB games, which will consequently determine the revenue of teams (Borland and MacDonald 2003; Martins and Cro 2018).

To this end, few researchers have directly analyzed the effective factors on the attendance of MLB franchises (Lemke et al. 2010), while many researchers studied other sports events such as soccer games (Coats and Humphreys 2012; Garcıa and Rodrıguez 2002; Hart et al. 1975; Villa et al. 2011). One of the most classical hypotheses to explain the attendance on sport events is based on the seminal work of Rottenberg (1956), implying that a more balanced sporting competition attracts more spectators due to higher outcome uncertainty (Cox 2018; Forrerst and Simmons 2002; Knowles et al. 1992). In essence, this so-called Louis-Schmeling paradox is to emphasize the competitive balance among teams so that the appropriate level of differences in the quality of rivals can be maintained (Neale 1964). For the same reason, two other studies (Reilly 2015; Martins and Cro 2018) also claimed that rivalry games attract more spectators. Several other studies emphasized the very nature of the team such as team quality (Garcıa and Rodrıguez 2002) and team performance (Dubin 2001) as contributing factors of the attendance demand.

In contrast, many other studies found that the psychological factor of spectators who strongly want to watch their home teams win is an effective determinant of the attendance demand. For example, Lemke et al. (2010) claimed that attendance to MLB games increases as the chance of the home team winning the game increases. Other researchers also reported that many spectators prefer to attend sport events when their teams play a much inferior team (Buraimo and Simmons 2008; Pawlowski and Anders 2012). Another group of researchers identified external factors as effective determinants of the attendance demand. For example, Serrano et al. (2015) reported that the quality of competing teams such as the market value of the players can have a positive impact on the attendance. In another study (Czarnitzki and Stadtmann 2002), team-specific values like supporter clubs and reputation are emphasized, which may explain why team-specific attendance prediction models predict better than a generalized model (Strnad et al. 2017). Other studies identified scheduling (Forrest and Simmons 2006), geographical distance between the cities where the teams are located (Buraimo and Simmons 2008), or the population of hometown and league membership period of a team (Dobson and Goddard 2011) as effective determinants of the attendance.

The most relevant set of previous studies to this paper, however, focuses on the economic factors of the attendance demand. For example, several studies tried to estimate the demand function based on ticket pricing (Garcia and Rodriguez 2002; Madalozzo and Villar 2009), the purchasing power of spectators measured by the income per capita of the home team's and the visiting team's region (Garcia and Rodriguez, 2002), or market size (Buraimo et al. 2009). In particular, Garcia and Rodriguez (2002) considered the opportunity cost of the consumer by including a dummy variable which provides information about whether or not the game is played on a weekend. In their study, it was assumed that the demand on the sport event on a weekday decreases because the opportunity cost of attending the event increases.

The central theme of this study is to estimate the attendance demand affected by the opportunity cost caused by the fact that spectators have to attend only a sport event among sport games due to schedule conflicts. We consider games of two other professional sports leagues, NBA and the National Hockey League (NHL), as substitutes to MLB games. Note that NBA and NHL games can be accidently scheduled on the same day at near location when and where MLB games are scheduled. Under such circumstances, we speculate that the attendance demand of MLB games decreases because the opportunity cost of attending to MLB games increases with available substitutes such as NBA and NHL games. However, the substitution effect considered in this study is different from the substitution effect in consumer choice theory, which relates a change in the relative price of a good to the amount of that good demanded by a consumer (Varian 2014).

We also assume that the substitution effect will have different impact on the attendance depending on the day of the game. Specifically, it is posited that the substitution effect on the sport event on a weekday be more significant due to a higher opportunity cost (Garcia and Rodriguez 2002). It is also hypothesized that the substitution effect is associated with fans' relative loyalty toward MLB games over NBA and NHL games, and hence its effect should be analyzed for each MLB team. In addition, we speculate that the substitution effect is affected by measures that reflect teams' current ranks in the league or performance in recent games.

Data Sets and Data Engineering

We downloaded several data sets through a data scraping program created with Python from multiple sources. First, the attendance data sets were scrapped from www.baseball-reference.com for each MLB game between 2008 and 2018. These data sets result in a total of 53,452 records with several variables such as game date, game day of the week, home and away team names, result, day/night game indicator, scores of home and away team, and so on. Next, we collected the schedule information of NHL and NBA games between 2008 and 2018 to indicate which MLB games had schedule conflicts with either NHL or NBA games. These data sets were scraped from www.hockey-reference.com for NHL data (a total of 14,027 records with information of game date, visiting and home team names, goal scores, attendance, and event city name) and from www.basketball-reference.com for NBA data (a total of 14,219 records with the same information as in NHL data). We summarize the initial data sets with the list of variables in Figure 1.

Variable	Description
Game ID	Unique identifier of the MLB game using Date, (Home) Team, and Attendance
Date	Date when the MLB game was played
Season	Year between 2008 and 2018 when the MLB game was played
Day of the Week	Day of the week when the MLB game was played
Location City	City where the MLB game was played
(Home) Team	MLB team that hosted the MLB game
Home/Away Indicator	Indicator whether the MLB game was a home or away game for Team
Opponent	Away team name
Result	Outcome of the game: Win, Loss, or Tie
Runs For	Number of Runs Team scored
Runs Against	Number of Runs Opponent scored
Record	Record of Team after the MLB game was played
Place In Division	Ranking of Team, based on Record compared to the other teams in the same division
Games Behind	Number of games that Team is behind the division leader in the standings
Duration	Length of the MLB game in hours
Night/Day	Indicator whether the MLB game was played in the night or day time
Attendance	Reported number of spectators
Streak	Numerical representation of Team's winning or losing streak
NBA Conflict	Indicator whether NBA games have schedule conflicts with the MLB game
NHL Conflict	Indicator whether NHL games have schedule conflicts with the MLB game
Total Conflict	Indicator whether NBA or NHL games have schedule conflicts with the MLB game

Table 1. List of Variables

Based on initial data sets, we engineer several variables for this study. We first create Boolean indicators to mark whether each MLB game has a schedule conflict with either NHL or NBA games. Next, we compute the average attendance (denoted as $Attd_{Avg(t,\,wd)}$) of MLB games for all the possible combinations of each MLB team (denoted as t) and each day of the week (denoted as wd). Then we use $Attd_{Avg(t,\,wd)}$ values to estimate the direction (i.e., positive or negative) and magnitude (i.e., large or small) of substitution effects due to conflicted NHL or NBA games bring. To estimate the substitution effect of either NHL or NBA game scheduled on the same day with a MLB game, we compute the attendance deviance for a chosen game g (denoted as $Attd\_Dev_g$) by subtracting $Attd_{Avg(t,\,wd)}$ from the attendance of a MLB game (denoted as $Attd_g$) as shown in Equation (1).

$$Attd\_Dev_g = Attd_g - Attd_{Avg(t,\,wd)} \quad (1)$$

Note that a positive (a negative) value of $Attd\_Dev_g$ represents an increase (decrease) of attendance to a specific MLB game that has a schedule conflict. Then, we compute the proportion of attendance deviance out of the average attendance (denoted as $P(Attd\_Dev_g)$ as follows:

$$P(Attd\_Dev_g) = Attd\_Dev_g \,/\, Attd_{Avg(t,\,wd)} \quad (2)$$

While we may use Equation (2) to estimate substitution effect of a specific MLB game, we do not intend to estimate the substitution effect for each MLB game with schedule conflict because such an estimate is not reliable. Instead, we intend to estimate substitution effects over multiple MLB games by aggregating factors

(denoted as F) such as each day of the week, each year, or each team. So, the substitution effect (denoted as *Sub*) over an aggregating factor F due to a schedule conflict league (denoted as $L \in$ {NHL, NBA, or Both}) is computed as follows:

$$Sub(F)^L = || Attd\_Dev^L{}_g \subseteq F ||^- / || D(F) ||^L \quad (3)$$

where $|| Attd\_Dev^L{}_g \subseteq F ||^-$ represents the total number of MLB games that have schedule conflicts with L league games, are a subset of MLB games aggregated over a factor F, and have a negative value of $Attd\_Dev_g$. Similarly, $|| D(F) ||^L$ represents the total number of MLB games that have schedule conflicts with L league games and are a subset of MLB games aggregated over a factor F. In essence, $Sub(F)^L$ in Equation (3) simply presents the proportion of MLB games with decreased attendance when they have schedule conflicts with NHL or NBA games. For example, the substitution effect of NHL games that have schedule conflicts with MLB games in 2018 (i.e., $Sub(2018)^{NHL}$) is computed by taking the proportion of the total number of 2018 MLB games with decreased attendance due to schedule conflicts with NHL games (i.e., $|| Attd\_Dev^{NHL}{}_g \subseteq 2018 ||^-$) out of the total number of 2018 MLB games that have schedule conflicts with NHL games (i.e., $|| D(2018) ||^{NHL}$). Note that we can use more intuitive metrics (e.g., the proportion of attendance deviance from each game that) to reflect the substitution effect for each game. However, in this study, we like to aggregate substitution effects over aggregating factors to obtain a more reliable measure and, to this end, the proportion of attendance deviance from each game is not suitable because it is not an additive measure.

Results and Discussion

Basic Statistics

Out of 53,452 MLB games, we found that 1,294 games were scheduled on the same date with NHL or NBA games. From these 1,294 games with schedule conflicts, we found that weekend games attracted more spectators than weekday games: On average, Saturday games recorded the largest attendance (34,763) followed by Sunday (32,129), Friday (32,008), Thursday (27,802), Monday (27,433), Wednesday (27,313) and Tuesday (26,993). However, the largest number of MLB games with schedule conflicts was observed on Wednesday (241 games) followed by Saturday (220 games) and Sunday (211 games), while the smallest number of MLB games with schedule conflicts was observed on Monday (127 games) and Thursday (144 games). Over years, we found that there was the largest number of MLB games with schedule conflicts in 2013 (162 games) followed by 2014 (142 games) and 2012 (139 games), while there was the smallest number of MLB games with schedule conflicts in 2010 (94 games) and 2017 (96 games).

We also found that the number of MLB games conflicted NHL or NBA league games varies significantly across MLB teams. For example, several teams such as BAL (Baltimore Orioles), CIN (Cincinnati Reds), KCR (Kansas City Royals), SDP (San Diego Padres), and SFG (San Francisco Giants) did not have a game with schedule conflict mainly because cities hosting these MLB teams do not operate other professional leagues. While most MLB teams (e.g., ARI, CLE, COL, and so on) had between 25 and 60 conflicted games with other leagues, few teams (e.g., BOS, CHC, CHW, and so on) had more than 60 conflicted games with other leagues. In particular, two MLB teams in Los Angeles suffered from the largest number of games with schedule conflicts: LAA (Los Angeles Angles; 114 games) and LAD (Los Angeles Dodgers; 121 games). However, more MLB games with schedule conflicts on the specific day of the week or team do not necessarily lead to the decrease or increase in attendance (i.e., substitution effect), which will be presented in the following sections.

Substitution Effects with Temporal Aggregation Factors

In this section, we present the substitution effects over temporal aggregation factors, day of the week and year. To this end, we computed the average attendance of all MLB games between 2008 and 2018 for each day of the week. Then we used Equations (1) through (3) to compute a set of $Sub(day\ of\ the\ week)^L$ values, the set of substitution effects caused by NHL, NBA, or any one of these league games with schedule conflicts ($L \in$ {NHL, NBA, or Any}) for each day of the week as an aggregating factor. We summarize our findings in Figure 1.

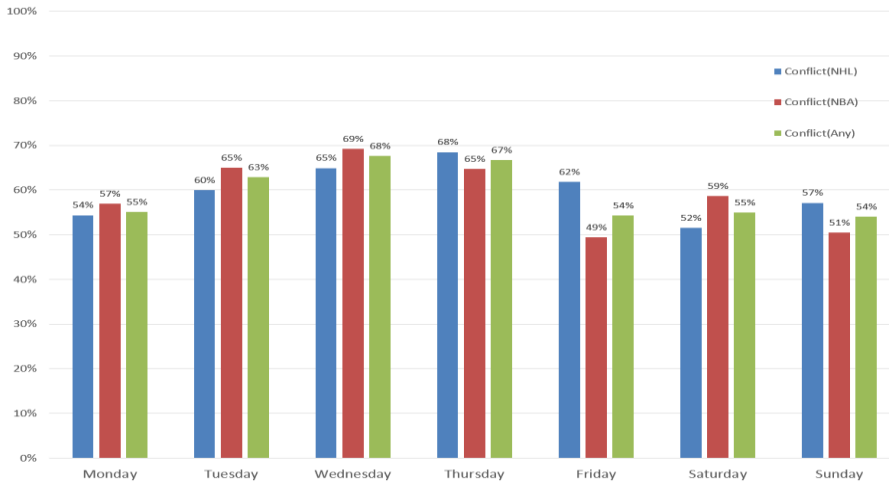

Figure 1. Substitution Effect of NHL and NBA Leagues over Days of the Week

According to Figure 1, the negative substitution effects by conflicted NHL games were more prominent on weekdays in order of Thursday (68%, indicating that 68% MLB games on Thursday with conflicted schedules with NHL games resulted in the decrease in attendance) followed by Wednesday (65%) and Friday (62%) than on weekends (Saturday (52%) and Sunday (57%)). The negative substitution effects by conflicted NBA games followed a similar patterns, more prominent on weekdays (Wednesday (69%), Tuesday and Thursday (65%)) than on weekends (Saturday (59%) and Sunday (51%)). These make sense from the spectators' perspective of opportunity costs. For example, most spectators have more free times during weekends than weekdays, making the opportunity cost of watching MLB games during weekdays is more expensive if all other things being equal. Therefore, it is very likely that spectators prefer watching NHL or NBA games during weekdays to watching MLB games during weekdays. This makes that negative substitution effects by NHL or NBA league games with schedule conflicts on the attendance demand on MLB games during weekdays are greater than those during weekends. We also find that Friday suffered less from the negative substitution effect by either conflicted NHL or NBA games than other weekdays. We attribute this finding to the fact that the opportunity cost of Friday is lower than those of other weekdays because it is the beginning of the weekends.

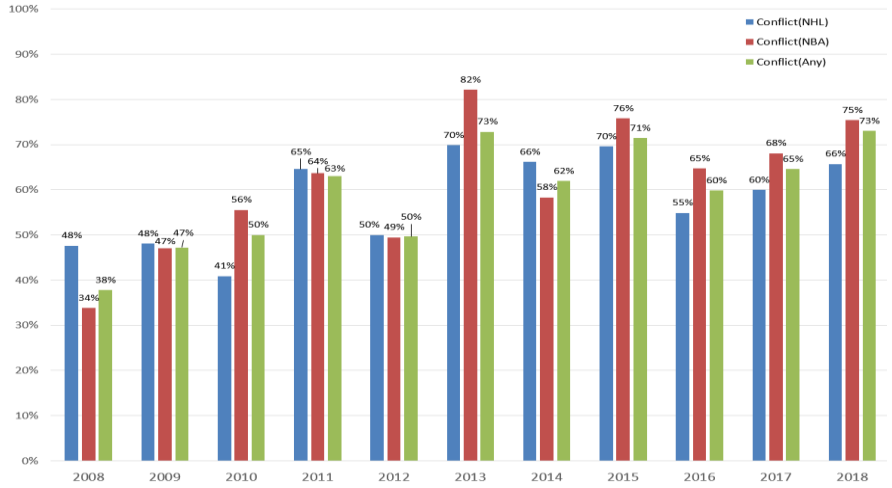

Figure 2: Substitution Effect of NHL and NBA Leagues over Years

Similarly, we aggregate the substitution effects of conflicted NHL or NBA games over another temporal aggregation factor, year, and summarize them in Figure 2. According to Figure 2, between 41% (2010) and 70% (2013 & 2015) of MLB games that had schedule conflicts with NHL games experienced a decrease in the attendance of spectators. We also find that NBA league games scheduled on the same day with MLB

games negatively affected the attendance of spectators in between 34% (2008) and 82% (2013) of MLB games. While we do not find any solid proof over years which alternative league (NHL or NBA) has more detrimental impact on the attendance of MLB games, we find that the substitution effects of both NHL and NBA games were prominent on specific years such as 2013, 2015 and 2018.

Substitution Effects with Team Aggregation Factor

In this section, we try to estimate the substitution effects with a team aggregation factor. To this end, we create and present in Figure 3 a chart with two axes, the primary vertical axis (left side in blue color) to represent the number of MLB games conflicted NHL or NBA league games and the secondary vertical axis (right side in red color) to represent the proportion of conflicted MLB games that suffered from negative substitution effect.

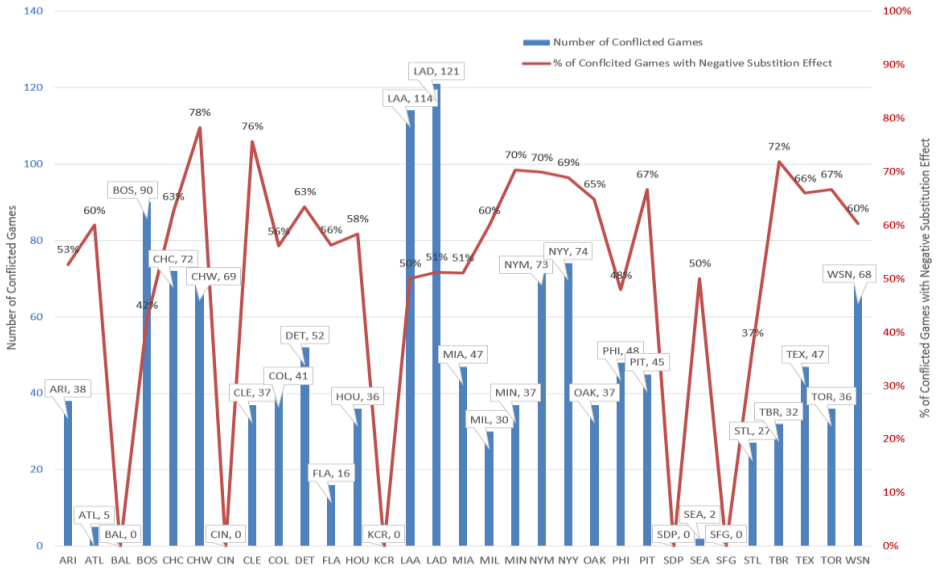

Figure 3: Substitution Effect across Teams

In terms of the proportion of conflicted MLB games with negative substitution effect, most teams with more than 60 conflicted games experienced negative substitution effect (= decrease in the attendance) from 37% (STL) to 78% (CHW) of conflicted MLB games. This great deviance of substitution effect indirectly insinuates that there are other MLB-team-specific factors to determine the magnitude of substitution effect. From limited data sets shown in Figure 3, among MLB teams with more than 60 conflicted games, MLB teams in the west division (e.g., LAA and LAD) suffered a relatively lighter substitution effect (50% to 51%), while several MLB teams in the central (e.g., CHC and CHW) and in the east division (e.g., NYM, NYY) experienced severe substitution effects (greater than 65%). Note that two MLB teams, St. Louis Cardinals (STL) and Boston Red Sox (BOS) that are well-known for their royal fans, experienced the lowest percentage of games with negative substitution effects (37% and 42%, respectively).

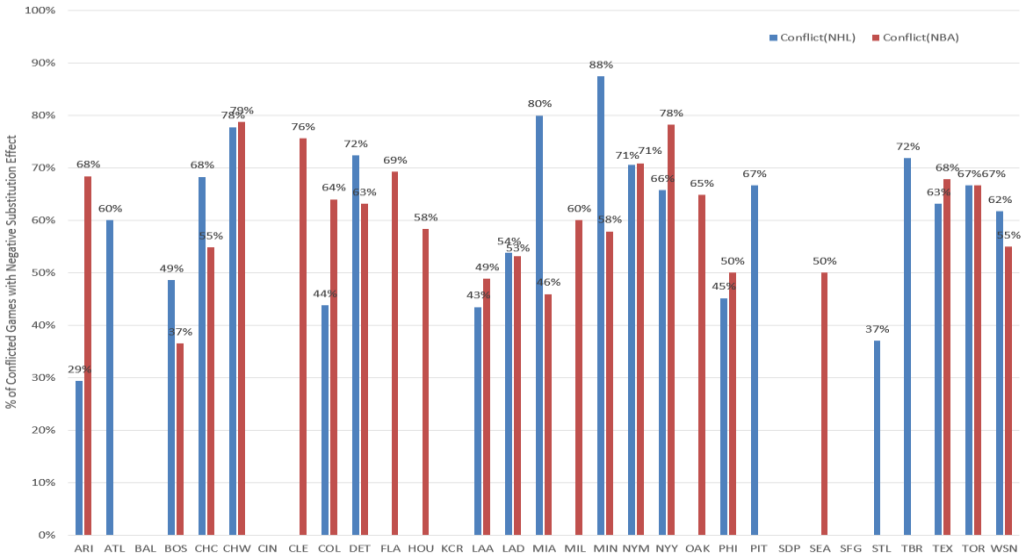

Figure 4: Substitution Effect of NHL and NBA Leagues across Teams

While substitution effects reported in Figure 3 present the aggregated substitution effects from both NHL and NBA league across MLB teams, substitution effects in Figure 4 show substitution effects for each league across MLB teams. Note that there are many MLB teams located in the cities that do not host NHL or NBA teams, which make them free from substitution effects by these alternative leagues. According to Figure 4, while several MLB teams (ATL, PIT, STL, and TBR) experienced substitution effect from only NHL league, several MLB teams (FLA, HOU, MIL, OAK, and SEA) experienced substitution effect from only NBA league. Most MLB teams suffered substitution effects from bother NHL and NBA league with similar magnitude. However, interestingly, several MLB teams suffered a much severe substitution effect from NBA league than from NHL league: ARI (68% vs. 29%), COL (44% vs. 64%), and NYY (66% vs. 78%). In contrast, several other MLB teams suffered a much severe substitution effect from NHL league than from NBA league: BOS (49% vs. 37%), CHC (68% vs. 55%), MIA (80% vs. 46%), and MIN (88% vs. 58%).

Substitution Effects with Team Performance Aggregation Factor

In this section, we try to estimate the substitution effects with team performance aggregation factors such as team places in the division and losing or winning streak in the past games. We first present a chart in Figure 4 that shows substitution effects of NHL or NBA leagues depending on MLB teams' standings in the division. Note that current 30 MLB teams are divided up evenly between the American League and National League and each of the leagues is divided into three divisions called the East, the Central, and the West. Therefore, MLB teams' standing in each division is always between 1 (best team) and 5 (worst team). However, the Houston Astros in the National League Central Division were reassigned to the American League West Division in 2013. So 23 records contain the sixth place teams between 2008 and 2012 although we will not investigate them carefully due to the lack of records and asymmetry compared with other ranks in our data sets. We speculate that MLB teams with lower standings will suffer from more severe substitutions effects than teams with higher standings. Our speculation is based on the findings in several studies (Lemke et al. 2010; Buraimo and Simmons 2008; Pawlowski and Anders 2015) that audiences are more likely to attend to sports events when the chance of their home team winning the game increases.

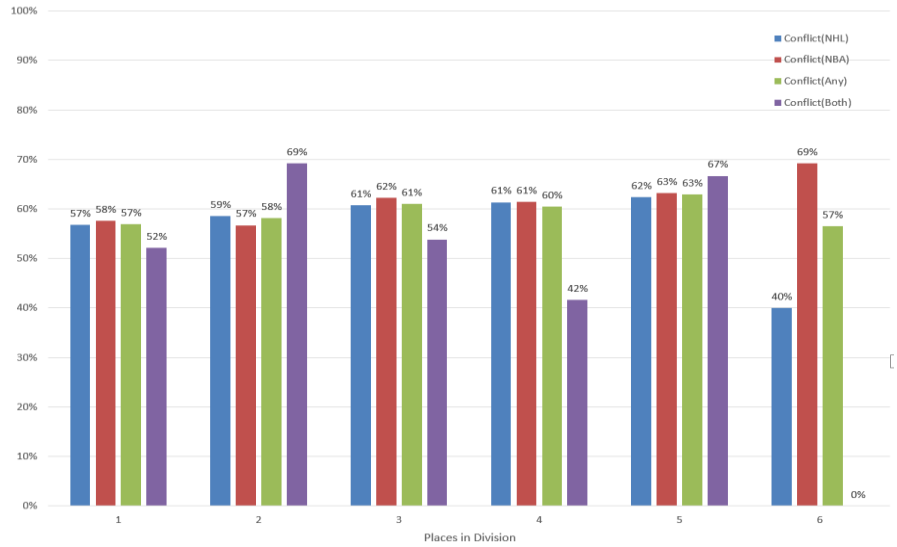

Figure 5: Substitution Effect with Team's Places in Division

Figure 5 confirms our speculation. According to Figure 5, the proportion of MLB games that have conflicted schedules with NHL games and lower attendance than average attendance is steadily increasing (i.e., from 57% to 59%, 61%, 61%, and 62%) as the standing of MLB teams in the division is worse (i.e., from 1st rank to 5th rank). Similarly, the proportion of MLB games that have conflicted schedules with NBA games and lower attendance than average attendance also shows an increasing trend (i.e., from 58% to 57%, 62%, 61%, and 63%) as the standing of MLB teams in the division is worse (i.e., from 1st rank to 5th rank). When we consider conflicted games of both NHL and NBA with MLB games, we observe that MLB teams in high standings suffered less from negative substitution effects than MLB teams in low standings in the division. While MLB teams ranked at 6th suffered most from conflicted NBA games (i.e., 69% of MLB games with conflicted schedules lead to less attendance than average), they suffered least from conflicted NBA games (i.e., only 40% of MLB games lead to lower attendance than average).

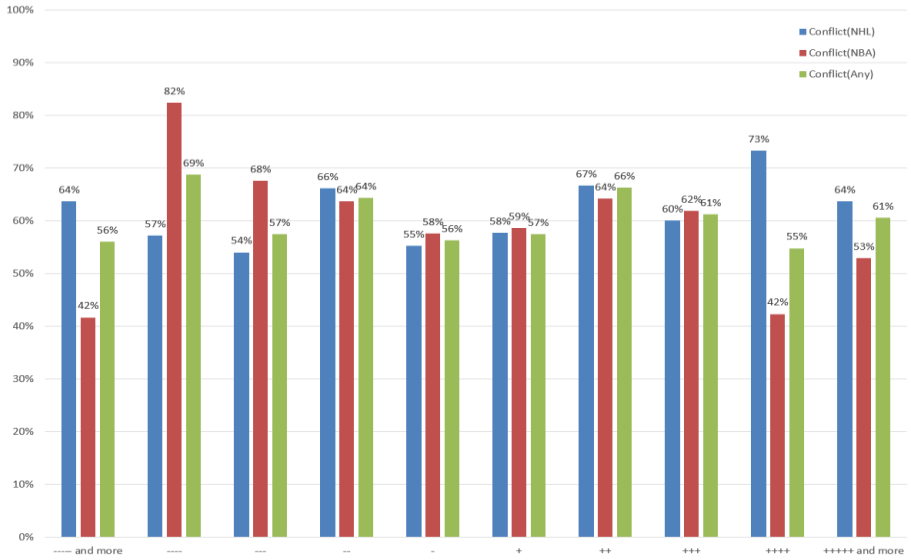

Figure 6: Substitution Effect with Team's Winning or Losing Streak

Another aggregation factor team performance we consider is the team's winning or losing streak. We anticipate that spectators are more likely to attend to sports events when the game between teams with rivalry relationships or similar ranks in the division is expected to be fun and exciting. Based on this speculation, we posit that MLB teams in a long winning or losing streak suffer from more severely than

other MLB teams. In our data sets, several MLB teams experienced somewhere between the worst scenario of 9-games-losing streak (denoted as "---------") and the best scenario of 9-games-winning streak ("+++++++++"). Therefore, we compute and present in Figure 6 the proportion of MLB games that have conflicted schedules with NHL games and lower attendance than average attendance for each value of team's winning or losing streak. Note that we combine the cases of winning or losing five or more games streak with conflicted schedules (25 records and 33 records out of 1,924 records, respectively) after considering the limited of records of such cases.

We first note that in general, the proportion of MLB games with lower attendance than average attendance is relatively low when teams are in a five or more games of losing streak, which contradicts to our speculation that spectators will not be interested in watching games when their home teams lost several games in a row in the past, which should lead to the higher proportion of MLB games with lower attendance. However, it sharply increases as teams are in a four games of losing streak as we expected, reflecting that spectators show their deepest disappointments in their teams and avoid to attend MLB games in stadium. Since then, more teams suffer gradually less decrease in attendance as they perform better, reaching at the lowest at the status of one game loss. We observe the symmetric trends as teams start to enjoy a case of winning streaks. As they are in more games of winning streaks, the proportion of MLB games with lower attendance starts to increase, peaks at a four games of losing streak, and decreases at a five or more games of winning streak.

Limitations and Future Work

In this study, we estimate the magnitude of the negative impacts (or substitution effects) caused by NHL or NBA games with schedule conflicts on the attendance demand of MLB games. In particular, we aggregate such substitution effects over three different factors such as temporal aggregation factors (e.g., years and days of the week), team aggregation factor (e.g., each MLB team), and team performance aggregation factor (e.g., each MLB team's performance). Overall, we observe that NHL and NBA games that have schedule conflicts with MLB games more significantly negatively impact the attendance on MLB games during the weekdays (in particular, Thursday and Wednesday) than MLB games during the weekend. We also observe that MLB teams in high standings suffer less from negative substitution effects than MLB teams in low standings in the division. In particular, when MLB teams are in a losing streak, spectators show their deepest disappointments in their teams and avoid to attend MLB games in stadium.

For future work, it is necessary to take a follow-up research to re-confirm or re-test findings presented in this study. Since the classical types of artificial neural networks have been widely adopted for various model tasks in sport literature (Maszczyk et al. 2011; McCullagh, 2010; Sahin and Erol 2017), we will use neural networks to identify MLB games that are most likely to suffer from negative substitution effects. Then, we intend to propose general marketing strategies that stakeholders of MLB teams may adopt to minimize the negative impacts of conflicted NHL or NBA games on the attendance demand on MLB games. Practically, such proposed marketing strategies could be very useful when stakeholders of an MLB team in a losing streak try to minimize the decrease of attendance to MLB games in stadium.

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