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TEAM PERFORMANCE CHARACTERISTICS WHICH INFLUENCE WINS IN THE NATIONAL HOCKEY LEAGUE

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ABSTRACT

This paper examines the influence of team performance characteristics on wins in the National Hockey League using a multiplicative model. Six of the thirteen independent variables are significant at the 99% level: power play percentage, whether a team scores first, save percentage, blocked shots, shootout shooting percentage, and faceoff percentage. Three of the thirteen independent variables were significant at the 95% level: major penalties, hits, and total shots. Variables that were not significant were: penalty minutes, shootout save percentage, giveaways and takeaways.

INTRODUCTION

Recently, Stair *et al* (2008) analyzed victories in the National Football League as a function of team performance variables. The authors suggest that such analysis is the precursor to spending decisions in the National Football League based on statistical analysis. It seems reasonable to assume that success in the National Hockey League is similarly correlated with various measures of team performance. Team offensive prowess, goaltending proficiency, and face-off wins are just a few examples of team performance characteristics which might be heavily correlated with team victories. This paper examines NHL team performance in various statistical categories and the resulting influence on overall team success. The results of this study should aid team officials when assembling a roster.

LITERATURE REVIEW

The majority of scholarly research examining production in the National Hockey League deals

with factors affecting either an individual player's salary or on-ice production. Curme and Daugherty (2004) found that French Canadian players are subject to an earnings penalty on Canadian NHL teams not located in Quebec. Lavoie (2000) similarly found that salary discrimination was pervasive, but not strong against French Canadian players in English Canada. Jones, Nadeau, and Walsh (1997) constructed a model of salary determination for both skill players and physical players. They found skill and physical players are valued and compensated differently, and each is compensated for proficiency in their respective roles. Colin, Jones, Nadeau, and Walsh (1999) found that a player's salary is not affected by his ethnicity. Idson and Kahane (2000) found that team attributes do affect individual salaries on the team. Voyer and Wright (1998) found that the best predictor of individual player performance in the NHL regular season is points scored per game in junior hockey. White and McTeer (1991) investigated the effects of a mid-season trade on a player's performance. Using data from selected trades since 1927, they found that a player's performance during a given season significantly improved after a trade. All of these papers focus on the individual player.

The research linking team success in the NHL to team performance variables is more limited. Heyne, Fenn, and Brook (2006) constructed a model that measures how team performance variables are correlated with team success. Using data from the five seasons spanning 1999-2004, they found that goals allowed, assists, total face-offs won, total face-offs lost, penalty minutes, major penalties, even-strength goals, power-play goals, short-handed goals, plus/minus, total saves, save percentage, and total shots were all correlated with an NHL team's success. They also suggest including giveaways, takeaways, hits, blocked shots, and penalty-kill and power-play percentages in future studies.

While Heyne, Fenn, and Brook (2006) produced a strong initial analysis of factors contributing to an NHL team's success, improvements can be made to their model. They included variables such as total goals allowed, even-strength goals, power-play goals, and short-handed goals. Obviously, the fewer goals a team gives up, the greater are its chances of winning. And, of course, the more goals a team scores, the greater are its chances of winning. The inclusion of these variables provides little insight concerning a team's efficiency in various aspects of the game. The model in this paper eliminates those variables related to total goals for and against and includes several new variables such as power-play percentage, penalty-kill percentage, and face-off percentage. It is important to note that Heyne, Fenn, and Brook did, in fact, suggest the inclusion of these percentages in any future research.

DATA

All data used in this model were collected from the National Hockey League's official website (www.NHL.com). The data cover six NHL regular seasons spanning from 2005-2011.

MODEL AND EXPECTED RESULTS

The NHL uses a unique scoring system to rank teams over the course of a season. Unlike other professional sports that rely simply on total wins or winning percentage, the NHL assigns point values (2 points for a win, 1 point for an overtime or shootout loss, and 0 points for a regulation loss) to each game. At the end of the regular season, the total number of points a team has

accumulated determines which teams qualify for the playoffs. Thus, the dependent variable for this model is team points.

We checked linear and non-linear functional forms. Several of the independent variables exhibit a non-linear relationship with the dependent variable. R^2 was higher for the non-linear functional form. For these reasons we chose a multiplicative functional form for this model. We checked several dummy variables for seasons, conferences, and teams. None were statistically significant so they are not included in the final model.

Our thirteen independent variables can be categorized as follows: (1) offensive performance variables, (2) defensive performance variables, (3) shootout variables, (4) penalty variables, (5) an offensive and defensive interaction variable, and (6) miscellaneous variables.

Offensive Performance Variables

Power-Play Percentage (PP%): This variable is the percentage of power-play opportunities on which a team scores a goal. The higher this percentage is, the more successful a team is on the power-play and the more goals they will score when given the advantage. Thus, as the power-play percentage increases, so too should a team's total points. Hence, the anticipated sign on this variable is positive.

Score First (SC1): This variable represents the number of games in which the team scores the first goal. Scoring first not only produces the one goal advantage, but it also provides momentum for the team that scored first. Thus, the hypothesized sign for this variable is positive.

Defensive Performance Variables

Save Percentage (SAV%): This variable represents the percentage of shots that a team's goalies successfully block. Because a team's save percentage is not kept officially, it was calculated as follows: Save Percentage = (Total Shots Allowed – Total Goals Allowed) / Total Shots Allowed. Though this rudimentary formula does not take into account empty net goals, the relatively low number of such goals would have a very minor influence on the percentages. The higher this percentage, the fewer goals a team should give up, and the higher its total points should be. Thus, the anticipated sign for this variable is positive.

Blocked Shots (BLK): This variable is the number of shots blocked by skaters other than the goalie over the course of a season. The hypothesized sign for this variable is positive, because as the number of blocked shots increase, so too should total team points.

Shootout Variables

Games that remain tied after one overtime period are decided by a shootout where individual players from each team get to take a free shot at the goal with only the goalie defending. Teams that win in a shootout receive two points. Teams that lose in a shootout receive one point.

Shootout Shooting Percentage (SOS%): This variable represents the percentage of shootout

attempts in which the team successfully scores a goal. As this percentage increases, so too should a team's total points. Thus, the anticipated sign for this variable is positive.

Shootout Save Percentage (SOSV%): This variable is the percentage of shootout attempts in which the team's goalie successfully stops the other team from scoring a goal. As this percentage increases, a team's total points should also increase. Therefore, the expected sign for this variable is positive.

Penalty Variables

Penalty Minutes (PM): This variable represents the total number of penalty minutes accumulated by a team over the course of a season. The more time a team spends in the penalty box, the more times it must spend short-handed, a severe disadvantage. Though not all penalties leave a team short-handed, most do. Therefore, as a team's total penalty minutes increases, total points should actually decrease. Thus, the anticipated sign is negative.

Major Penalties (MAJ): This number is the total number of five-minute major penalties a team draws over the course of a season. While these penalties can be issued for various reasons, the vast majority of them are the result of fights between players from opposing teams. Thus, they are usually coincidental in nature, meaning that both teams send a player to the penalty box for five minutes without having to play short-handed for any period of time. The fact that major penalties don't leave a team short-handed removes the negative influence found with regular penalty minutes. Therefore, could it be true that major penalties actually have a positive influence on total team points? Fights may result in changes in momentum during the course of a game. Teams playing poorly prior to a fight may be given an emotional spark when seeing one of their teammates involved in a fight. In many cases, the team responds by playing much better after the fight. However, both teams are equally capable of receiving an emotional lift from a fight, regardless of which team was the instigator. An increase in major penalties could lead to either an increase or decrease in a team's total points. Therefore the sign could reasonably be either positive or negative.

Miscellaneous Variables

Face-Off Percentage (FO%): This variable is the percentage of face-offs in which the team successfully gained possession of the puck. By winning face-offs, a team not only gains control of the puck and has an opportunity to score, but it also prevents the other team from doing the same. As face-off percentage increases, total team points should also increase. Hence, the expected sign on this variable is positive.

Giveaways (GV): This variable represents the number of times a team turns the puck over throughout a season. As this total increases, total points should decrease. Therefore, the hypothesized sign of this variable is negative.

Takeaways (TK): This variable represents the number of times a team steals the puck from its opponent over the course of a season. As this number increases, so too should a team's total points. The expected sign for this variable is positive.

Hits (H): This variable is the number of times a team checks its opponent throughout the course of a season. While physical aggressiveness varies from team to team, teams that check more often generally control the flow of the game. And in some cases, the more physical team can intimidate its opponent. Thus, it would be reasonable to suggest that as a team's hits increase, so should its total points. Therefore, the hypothesized sign for this variable is positive.

Offensive/ Defensive Interaction Variable

Total Shots (TS): This variable combines total shots for and total shots against. It is an axiom in many sports that defense wins championships. Therefore, teams that play more defensive style of hockey may tend to have more wins than teams that play more offensive style of hockey. More offensive minded teams should shoot quicker and more often. This should also allow the opponent to take more shots against the team. Therefore teams consistently involved in games where there are more total shots tend to be more offensive minded. Teams consistently involved in games where there are fewer total shots are therefore more defensive minded. If defense wins championships, then this variable should have a negative sign. More defensive minded teams should experience lower total shots in their games and accumulate more points from more victories.

To test for seasonal, conference, and team effects, our model also originally included several dummy variables. Our data covers six seasons; we checked a dummy for five of them. Since there may be differences between the Eastern and Western Conferences of the NHL, we checked a dummy for the Eastern Conference. Also, we checked dummy variables for several teams, including the Stanley Cup champion each year. All of these dummies were insignificant. Therefore, they were excluded from the final model.

REGRESSION RESULTS AND ANALYSIS

The final regression results included here do not contain several of the variables discussed in the previous section of this paper. We found that multicollinearity existed between save percentage and penalty kill percentage. Therefore we dropped penalty kill percentage from the model. We also found, not surprisingly, that multicollinearity existed between shots for, shots against, and total shots. Therefore we dropped total shots for and total shots against. We maintained total shots because we think it is a proxy for whether a team is offensive minded or defensive minded.

Because there are a maximum number of points a team can accumulate in the regular season (164), theoretically the multiplicative functional form should provide the best fit to these data. The estimated equation (with the t-statistics in parentheses) is:

$$\textbf{Points} = 5.6004\text{E-}10\ (PP\%)^{0.30}\ (SC1)^{0.39}\ (SAV\%)^{5.55}\ (BLK)^{-0.16}\ (PM)^{-0.03}\ (MAJ)^{-0.06}$$

T stats	(-5.98)	(5.82)	(6.33)	(7.32)	(-2.94)	(-0.65)	(-2.60)

$$(SOS\%)^{0.08}\ (SOSV\%)^{0.06}\ (FO\%)^{0.50}\ (GV)^{-0.01}\ (TK)^{0.03}\ (H)^{0.09}\ (TS)^{-0.38}$$

(3.75)	(1.22)	(2.64)	(-0.01)	(0.72)	(2.09)	(-2.10)

Adjusted R^2 = 0.69

In the explanation that follows, for the independent variables that are not measured as percentages, the estimated exponents are the elasticities of team points with respect to the independent variables. For the independent variables that are already measured as percentages, we do not discuss elasticities, since elasticities in that case would require calculating the percent change in something that is already a percentage. In that case, we report the change in team points for a 1 percent increase from the minimum observed value of the independent variable and the change in team points for a 1 percent decrease from the maximum value of the independent variable assuming all the other independent variables remain at their mean value. A comparison of those results will give some indication of how curvilinear the relationship between the independent variable and team points is.

Offensive Performance Variables

The estimated exponent of Power Play Percentage (PP%) is positive, as predicted, and significant at the 99% level. Actually, it had the third highest t-statistic in the model. The estimated exponent of Power Play Percentage indicates that the effect of Power Play Percentage on team points increases at a decreasing rate.

In the six years of data we collected, the greatest Power Play Percentage was 25.5 by the Detroit Red Wings in the 08-09 season, and the smallest was 11.8 by the Chicago Black Hawks in the 2006-2007 season. The mean was 18.01. A one percent increase in Power Play Percentage from 11.8 to 12.8 will increase team points by 2.001 points. On the other hand, a one percent decrease in Power Play Percentage from 25.5 to 24.5 will decrease team points by only 1.21.

The estimated exponent of Score First (SC1) is .39 and is significant at the 99% level. This exponent has the second highest t-statistic of all the independent variables. The effect of scoring first on points also increases at a decreasing rate. In the six years of data we collected, the maximum number of times a team scored first in a season was 56 by the San Jose Sharks in the 2007-2008 season. The minimum number of times a team scored first was 29 by the Phoenix Coyotes in the 2006-2007 season. The estimated exponent of score first is the estimated score first elasticity of team points. It indicates that a one percent increase in scoring first will increase team points by 0.39 percent.

Defensive Performance Variables

The estimated exponent of Save Percentage (SAV%) is positive, as predicted, and significant at the 99% level. In fact, this variable had the highest t-statistic in the model. In the five years of data we collected, the minimum Save Percentage was 88.41 by the Tampa Bay Lightning in the 2006-2007 season. The maximum save percentage was 92.95 by the Boston Bruins in the 2010-2011 season. This means that as a team's save percentage increases, so too should total points. The relationship between team points and save percentage increases at an increasing rate, but only slightly. If the team with the lowest save percentage increases it's save percentage by one percent it will gain 5.142 points. If the team with the highest save percentage experiences a reduction in save percentage by one percent, it will lose 6.141 points.

The estimated exponent of blocked shots (BLK) is unexpectedly negative and significant at the 99% confidence level. This indicates that more shots blocked by a team means that team will have fewer victories. Perhaps this variable is picking up offensive opportunities by the opposing team. If the opposing team has more offensive opportunities, that may result in more shots blocked. The estimated exponent of this variable is the blocked shots elasticity of total points. It indicates that a one percent increase in blocked shots will decrease total team points by 0.16 percent.

Penalty Variables

The estimated exponent of Penalty Minutes (PM) is negative and not significant.

The estimated exponent of Major Penalties (MAJ) is negative and significant at the 95% level. This variable has a very large range in the NHL. The minimum number of major penalties assessed to a team in the six seasons analyzed was 7 by the Detroit Red Wings in the 2005–2006 season. The maximum number of major penalties assessed during a season was 82 against the Anaheim Mighty Ducks in the 2008–2009 season. The estimated coefficient of this variable indicates that a one percent increase in major penalties results in a 0.06 percent decrease in team points. This indicates that teams that get in fights more frequently in the NHL win fewer games.

Shootout Performance Variables

The estimated parameter on the natural log of Shootout Shooting Percentage (SOS%) is positive and significant at the 99% level. As predicted, as a team's shootout shooting percentage increases, its total points increase, as well. The minimum shootout percentage in our data was a woeful 5.9 percent by the Carolina Hurricane in 2006-2007. The maximum shootout percentage was 58.3 by the San Jose Sharks in 2006-2007. A 1 percent increase from the minimum results in a 1.01 increase in total points. On the other hand, a 1 percent decrease from 58.3 percent to 57.3 percent results in a 0.133 decrease in total points.

The estimated exponent of Shootout Save Percentage (SOSV%) is positive, as expected, but not significant.

Miscellaneous Variables

The estimated exponent of Face-Off Percentage (FO%) is positive and significant at the 99% level. The minimum observed face-off percentage during the six seasons was 44.2 by the Edmonton Oilers during the 2010-2011, season. The maximum face-off percentage was 55.6 by the San Jose Sharks in 2009-2010, season. A 1 percent increase in face-off wins from 44.2 to 45.2 results in a 0.973 increase in total points. A 1 percent decrease from 55.6 to 54.6 percent results in a 0.876 decrease in total points.

The exponent for Giveaways (GV) is negative and not significant, meaning that a team's total giveaways do not have a significant influence on total points.

The estimated parameter on Takeaways (TK) is positive, as predicted. This coefficient, however, is not significant, indicating that a team's total takeaways do not significantly impact total points.

The estimated exponent of Hits (H) is positive and significant at the 95% level. The estimated exponent of this variable is the hits elasticity of total points. It indicates that a one percent increase in hits will increase total team points by 0.09 percent.

Offensive/ Defensive Interaction Variable

The estimated exponent of Total Shots (TS) is negative, and significant at the 95% level. The elasticity of (TS) indicates that a one percent increase in (TS) will decrease total team points by 0.38 percent. According to our logic, more total shots for and against in a game occurs *with more offensive-minded teams.* The sign of the estimated coefficient being negative would indicate that more offensive minded teams win less. This indicates that defense not only wins championships, but also more regular season games in the NHL.

CONCLUSIONS

Six of the thirteen independent variables are significant at the 99% level: power play percentage, whether a team scores first, save percentage, blocked shots, shootout shooting percentage, and faceoff percentage. Three of the thirteen independent variables were significant at the 95% level: major penalties, hits, and total shots. Variables that were not significant were: penalty minutes, shootout save percentage, giveaways and takeaways.

Two of the variables that are significant at the 99% level are power play percentage, and whether a team scores first. These are the only two offensive variables that have a significant positive impact on team points. The defensive variables found to have a significant impact on team points in a positive direction were hits and save percentage. We thought blocked shots would also have a positive impact on team points; however its coefficient was negative and significant. This may indicate that teams desperately blocking shots by sliding across the ice are not playing sound defense otherwise.

We also found that major penalties have a significant negative effect on team points. This may indicate that teams that fight frequently are negatively impacting their performance. Or it may indicate that teams that lose frequently become frustrated and tend to fight more often. We also found that total shots have a negative impact on team points. We believe that teams involved in games with more total shots can be thought of as offensive minded teams. This seems to indicate that teams that emphasize defense win more regular season games.

The importance of save percentage also helps explain the insignificance of other variables. Quite simply, failure to save a shot results in a goal for the opposing team. On the other hand, a takeaway or giveaway doesn't necessarily mean that the play will result in a goal for the opposing team, since they still must get the puck past the goaltender. Thus, it can be said that the goaltender has the ability to influence the outcome of a game more so than any forward or defenseman.

While shoot-outs were initially seen by some as a sort of gimmick instituted by league officials to increase the popularity of the NHL after the 2004-2005 lockout, the results of this model show that the new tie-breaking format is significant in determining a team's total points. Thus, general managers should note a player's shootout shooting percentage when assembling a roster. Though shootout performance obviously isn't the sole factor in determining a player's value, there is no doubt that it should be considered in a general manager's decision about a player.

More research needs to be done concerning team production in the National Hockey League. Rather than simply analyzing team statistics and overall team success, the effects of individual player characteristics on overall team success could be explored further. This would provide general managers with an empirical basis for their roster moves. Also, due to the extreme significance of goaltending, research could be done relating junior and college statistics of goaltenders to success in the NHL. This would, again, give general managers empirical support for their decisions to draft or trade for goaltenders. This type of analysis is now being used as the basis for spending decisions designed to increase wins in Major League Baseball, and the National Football League. Future research needs to be done to indicate how teams in the NHL can spend efficiently to influence team performance characteristics and victories.

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