Assessing the Burdens of Leadership: The Effects of Formal Leadership Roles on Individual Performance

MLT

Introduction

In a 2004 study, David V. Day, Hock-Peng Sin, and Tina T. Chen investigated the effects of formal leadership roles on individual performances over time using data from the National Hockey League (NHL). More specifically, this study considered how the designation of team captain affects the performance of NHL players. Viewing captaincy as a "treatment," the researchers studied whether captaincy had improved individual performance and whether there were player characteristics that related to the impact of captaincy on one's performance. This study intended to evaluate the effect of leadership in hockey and to relate the association with other sports (and contexts). The researchers hypothesized that how teams assemble, perform, and eventually disband in sports and the real world (e.g., workplace) are fundamentally related, namely that a new member can evolve into an important leader of the team over time by earning the team's respect.

The data for this study described 201 NHL players (information about each player, including yearly performance statistics, was compiled from "Total Hockey: The Official Encyclopedia of the National Hockey League") who also met two additional criteria. First, the player had to be a captain for at least one year during his career. Second, the player must have played in the modern era of the NHL (beginning with the 1967-68 season). All players were male, and approximately 70% occupied offensive positions. In total, the data tracked the performance of 201 NHL players for up to 10 years after being designated as a captain for the first time. At the time the data was collected, approximately 137 were still active in the NHL, and not all served as the captain of their respective teams. This means that players' careers are not distributed equally over time.

The researchers found through correlational analysis that players performed better during an NHL season when they served as a captain relative to non-captains during the same season and themselves in other seasons when they were not a captain. The researchers also concluded that captaincy affords players more opportunities to be successful. The multilevel model surprisingly challenged the existence of a positive correlation trend between captaincy and individual performance. The model showed that player performance changed over time and that the overall trend was negative. One explanation is that a hockey player's (or any athlete's) skillset or talent is not constant or changing at a fixed rate. Every athlete evolves uniquely based on his/her sport, environment, and training regimen. In the NHL, athletes tend to ascend before peaking in their mid-to-late twenties, and then decline in their early-to-mid-thirties as the physical nature of the sport and the accumulation of injuries present serious issues. The researchers, therefore, argued that since players are typically given captaincy towards the later part of their career, the negative performance trend from the multilevel model is more likely a consequence of aging (rather than an adverse effect of leadership).

Methods

The researchers fit a multilevel model with two levels. Importantly, the final model presented below was obtained after fitting full models at each level and dropping any statistically insignificant effects. In other words, every fixed effect in the final model is statistically significant (at least at the 5% level). It is important to begin by describing the correlation structure of the data. The observational unit at level one is a player in a given season. The observational unit at level two is a player over their career (i.e., across multiple seasons).

The response variable of interest is a player's adjusted points in a season. Points are computed as the sum of goals and assists and then adjusted for the number of total games in the respective season, the average number of goals per game in the respective season, and the number of games that the player appeared in during the season. This allows players to be compared across time (as the NHL's scheduling format has changed since 1967) using the "most important statistic of an individual hockey player's performance," which also accounts for players who may have missed significant time in a particular season. The number of unadjusted points could be modeled as a Poisson variable (a count per unit of time). However, the adjusted response variable can theoretically take on any non-negative value. Thus, the response should be modeled as a continuous random variable. Given these specifications, the Gamma, Lognormal, or Weibull (often used in survival analysis) distributions may be appropriate for modeling the number of adjusted points. To be clear, the authors do not specify the distribution of the response variable (or provide any visualizations of the distribution).

Next, we can describe the levels of the model formally. Let $j = 1, \ldots, 201$ and $i = 0, \ldots, 9$ (season zero corresponds to the first season that the player is a captain). Assume Y_{ij} denotes the number of adjusted points totaled by player j in season i (response variable). Assume x_{1j} counts the number of seasons player j was a captain before the given season. Assume x_{2j} is an indicator of whether player j was a captain during a given season (coded as 1: yes, 0: no). Assume x_{3j} denotes the height of player j in inches (grand-mean centered). Assume x_{4j} denotes the position of player j (coded as 1: defense, 0: offense; uncentered). Assume x_{5j} denotes the number of seasons player j played in the NHL before becoming a captain for the first time (uncentered). Assume x_{6j} denotes the age of player j at the time of his first captaincy (grand-mean centered). Assume x_{7j} denotes the total number of times player j was a captain during his career (uncentered).

The j-th level one model (there are 201 level one models in total) is

$$Y_{ij} = a_{0j} + b_{1j}x_{1j} + \gamma_{20}x_{2j} + \epsilon_{ij}.$$

There are two level two models—one for the intercept (a_{0j}) and another for the slope coefficient (b_{1j})—

$$a_{0j} = \gamma_{00} + \gamma_{01}x_{3j} + \gamma_{02}x_{4j} + \gamma_{03}x_{5j} + \gamma_{04}x_{6j} + \gamma_{05}x_{7j} + u_j$$

$$b_{1j} = \gamma_{10} + \gamma_{11}x_{4j} + \gamma_{12}x_{6j} + v_j.$$

Substituting the level two models into the j-th level one model, we obtain the following composite model

$$\begin{aligned}
Y_{ij} &= \gamma_{00} + \gamma_{01}x_{3j} + \gamma_{02}x_{4j} + \gamma_{03}x_{5j} + \gamma_{04}x_{6j} + \gamma_{05}x_{7j} + u_j + (\gamma_{10} + \gamma_{11}x_{4j} + \gamma_{12}x_{6j} + v_j)x_{1j} + \gamma_{20}x_{2j} + \epsilon_{ij} \\
&= [\gamma_{00} + \gamma_{10}x_{1j} + \gamma_{20}x_{2j} + \gamma_{01}x_{3j} + \gamma_{02}x_{4j} + \gamma_{03}x_{5j} + \gamma_{04}x_{6j} + \gamma_{05}x_{7j} + \gamma_{11}x_{1j}x_{4j} + \gamma_{12}x_{1j}x_{6j}] + [u_j + v_jx_{1j} + \epsilon_{ij}].
\end{aligned}$$

To be clear, there is no level two model for the coefficient associated with x_{2j} because there is no variability in this effect (according to the article). The estimated fixed effects are γ_{00}, γ_{10}, γ_{20}, γ_{01}, γ_{02}, γ_{03}, γ_{04}, γ_{05}, γ_{11}, and γ_{12}. γ_{00} represents the average adjusted points across all players and all seasons. γ_{10} represents the average change in the j-th player's adjusted points for every additional previous year of captaincy (before the given season). γ_{20} represents the average change in the j-th player's adjusted points if the player was a captain during the given season. γ_{01} represents the average change in the j-th player's adjusted points for every additional inch in height. γ_{02} represents the average change in the j-th player's adjusted points if the player occupies a defensive position rather than an offensive one. γ_{03} represents the average change in the j-th player's adjusted points for every additional year played in the NHL before becoming a captain for the first time. γ_{04} represents the average change in the j-th player's adjusted points for every additional year in the player's age when he first became a captain. γ_{05} represents the average change in the j-th player's adjusted points for every additional year of captaincy during his career. γ_{11} represents the average difference in the effect of an additional previous year of captaincy (before the given season) for offensive and defensive players. γ_{12} represents the multiplicative effect of the number of years the player has served as a captain before the given season and the player's age at the time of his first captaincy. All of these interpretations are under the assumption that the rest of the fixed effects are held constant.

The error terms (which describe the behavior of the random effects) are u_j, v_j, and ϵ_{ij}. We know

$$\begin{bmatrix} u_j \\ v_j \end{bmatrix} \sim N\left(\begin{bmatrix} 0 \\ 0 \end{bmatrix}, \begin{bmatrix} \sigma_u^2 & \sigma_{uv} \\ \sigma_{uv} & \sigma_v^2 \end{bmatrix}\right),$$

where the error associated with the j-th player in season i is $\epsilon_{ij} \sim N(0, \sigma^2)$ and the variance components to estimate are σ, σ_u, σ_v, and ρ_{uv} ($\sigma_{uv} = \rho_{uv}\sigma_u\sigma_v$). u_j represents the deviation of player j from the mean number of adjusted points (averaged across all seasons) scored by players who have been a captain at least once before the given season (but not a captain in the given season), after accounting for height, position, number of years played before becoming a captain for the first time, age at the time of the first captaincy, and the total number of seasons as captain (over an entire career). v_j represents the deviance of player j from the mean difference in the number of adjusted points (averaged across all seasons) scored by players who have been a captain at least once before the given season (but not a captain in the given season) and players who are a captain in the given season, after accounting for position and age at the time of the first captaincy.

Results

Based on the article, $\hat{\gamma}_{00} = 1.063$, $\hat{\gamma}_{10} = -0.06$, $\hat{\gamma}_{20} = 0.045$, $\hat{\gamma}_{01} = -0.021$, $\hat{\gamma}_{02} = -0.365$, $\hat{\gamma}_{03} = 0.029$, $\hat{\gamma}_{04} = -0.043$, $\hat{\gamma}_{05} = 0.046$, $\hat{\gamma}_{11} = 0.021$, and $\hat{\gamma}_{12} = -0.005$. Furthermore, $\hat{\sigma} = 0.178$, $\hat{\sigma}_u = 0.317$, and $\hat{\sigma}_v = 0.023$. The article does not provide a value for $\hat{\rho}_{uv}$. It is suggested, however, that $\rho_{uv} = 0$ (i.e., the random effects are independent).

We begin by interpreting the fixed effects. The average adjusted points across all players and all seasons is 1.063. For each additional inch of height, we expect a player's adjusted points to decrease by 0.021, holding all else (i.e., all other fixed effects in the composite model) constant. For players occupying defensive positions, we expect their adjusted points to be 0.365 fewer than the adjusted points for offensive players, holding all else constant. For every additional year played in the NHL before becoming a captain for the first time, we expect a player's adjusted points increase by 0.029, holding all else constant. For each additional year older a player was when he first became a captain, we expect his adjusted points to decrease by 0.043, holding all else constant. For each additional time a player was a captain during his career, we expect his adjusted points to increase by 0.046, holding all else constant. For every additional previous year of captaincy (before the given season), we expect a player's adjusted points to decrease by 0.06, holding all else constant. If the player was a captain during the given season, we expect his adjusted points to be 0.045 higher than the adjusted points for a non-captain, holding all else constant. For defensive players, each additional previous year of captaincy (before the given season) is expected to increase their adjusted points by 0.021 more than the effect for offensive players, holding all else constant. The multiplicative effect of the number of years a player has been a captain before the given season and the player's age at the time of his first captaincy on adjusted points is -0.005, holding all else constant.

Moreover, we can interpret the variance components. The estimated standard deviation in the residuals (errors in the predicted adjusted points) for each player in a given season is 0.178. The estimated standard deviation in a player's adjusted points in a given season from the mean number of adjusted points (averaged across all seasons) scored by players who have been a captain at least once before the given season (but not a captain in the given season) is 0.317, after controlling for height, position, the number of years the player played before becoming a captain for the first time, the age of the player at the time of his first captaincy, and the total number of times the player was a captain during his career. The estimated standard deviation in a player's adjusted points in a given season from the mean difference in the number of adjusted points (averaged across all seasons) scored by players who have been a captain at least once before the given season (but not a captain in the given season) is 0.023, after controlling for position and age at the time of the first captaincy. Finally, the estimated correlation between player-to-player differences in a_{0j} and player-to-player differences in b_{1j} (across entire careers) is $\hat{\rho}_{uv}$.

Some important takeaways in regards to leadership are from the level one models. Each additional previous season in which the player was a captain is a negative predictor of the player's expected adjusted points in the current season. This might suggest that the burden of leadership takes a toll on the player's adjusted points over time, although the authors also mentioned that aging could be a factor in this relationship. In the level two model for the intercept (a_{0j}), each additional time a player was a captain throughout his career was a positive predictor of that player's average adjusted points. This suggests that players who are captains more often throughout their careers are more likely to score more adjusted points in general; in other words, more leadership roles over time suggest a better performance in general. Another important takeaway is that when looking at the level one model, players on average performed 0.045 adjusted points better in seasons when they were captain compared to seasons when they were not. While some of this difference could be from players not playing as much in early seasons when they are less likely to be a captain, it is still an interesting result. From a real-world perspective, this would suggest that on average, being a leader has a positive impact on the overall performance of an individual.

These results bring up the idea of role overload vs. role accumulation. The model suggests that role overload improves an individual's performance ($\hat{\gamma}_{20} = 0.045$) as NHL players, on average, perform better in seasons when they are a captain compared to seasons when they are not a captain (even though they are taking on the additional responsibility and burdens of being a leader). Our model also suggests that role accumulation, on average, improves an individual's performance ($\hat{\gamma}_{05} = 0.046$) as NHL players with more experience as a captain tend to have higher adjusted points. Another relationship we would like to explore further is the relationship between skill and captaincy. It is possible that highly skilled players (who tend to play in the league for more seasons) have a higher probability of becoming a captain than lesser-skilled players.

Communication

Audience The primary audience of this article consists of individuals who are interested in leadership and the relationship between leadership roles and performance (e.g., academics who study organizational leadership, key decision makers in industry). The authors apply rigorous statistical methodologies to analyze the data but communicate their key conclusions in non-technical language. The study is especially applicable to anyone who regularly functions on a team. Professionals can gain a better understanding of how their team leader operates and how a position of leadership/management could affect performance, particularly in the "Practical Implications" section of the article. Those who are considering pursuing leadership positions could use these findings to weigh whether they are ready to accept elevated responsibilities and whether they have enough bandwidth to move up the ladder. Current leaders could use this article to reflect on how their position has affected their ability to do the job they are expected to do. Those who are delegating positions of leadership can use these findings to discern how their decisions may affect the performances of those who they promote.

An important caveat to all of this is that the nature of leadership roles varies greatly from organization to organization. The authors found that NHL captaincy positively affects performances, "but there are also some unique aspects of this type of leadership role that should be acknowledged." These include the extremely public nature of this role along with the intense pressure NHL players face on a game-to-game basis. Furthermore, it takes a set of unique characteristics to make it to the NHL, such as grit, drive, and competitiveness that the average person may not possess. Thus, this study raises the question of how the effect of a formal leadership position varies by environment.

Methods In their article, the authors clearly identify the fixed effects at each level of the model. They also provide some details about the model fitting procedure. Specifically, the authors mention that "random coefficient modeling was implemented using the hierarchical linear modeling statistical program to simultaneously estimate" the effects at each level. Moreover, the authors followed the steps outlined in Bliese & Ployhart (2002) when building the level one model; they started with a simple regression model and ended with a complete growth model by successively adding complexity to the model. They do not provide additional information about the hierarchical linear modeling statistical program (e.g., where to find it, what language is it written in?). The authors provide explanations for their modeling choices. For instance, the researchers discuss how, after considering linear, quadratic, cubic, and other higher-order functions to model the time variable, they found that the only significant time function was linear and negative. The authors did provide modeling equations at each level; however, due to typos, the equations were unclear. For instance, in the level two model for the intercept (a_{0j}), the coefficients associated with two different fixed effects are the same. However, based on the table of estimated coefficients (with p-values), the effects are distinct. Also, the article states that certain fixed effects have been grand-mean centered but provides no further clarification. Overall, the authors likely assumed that the readers would be at least moderately proficient in statistics (or data analysis) and that they would have some prior knowledge of multilevel modeling. Nevertheless, we stand by the assertion that this article (specifically its conclusions) is relatively accessible to individuals without extensive statistics backgrounds. At the end of the day, grasping the key conclusions of the study is most important for readers working in other disciplines.

Graphs and Figures In this article, the researchers did not include any graphs in either the EDA or results sections. Instead, the researchers use tables to aid in the descriptions of the predictors at each level. For level one, they display both summary statistics and intercorrelations of performance for each season after a player was designated as captain. For level two, the researchers display a table that includes both descriptive statistics and correlation coefficients for the six predictors. For EDA, the researchers chose to include two separate correlation tables to present the correlation values of performance, or the number of adjusted points scored in a given season, at the first level, and between the different predictors at the second level. At the first level, the authors created a table that compared the correlation coefficient of a particular season's performance to that of every other season. This resulted in a lower-triangular table with season nine having a correlation coefficient for years zero through eight, where year zero signifies the first season a player is a captain. Additionally, the indication of being a captain is compared with the number of seasons since being deemed a captain. This accounts for players that lose their captaincy and the correlation coefficient signifies the strength of the relationship between captain status and season predictors (not with adjusted points). The table also contains the mean and standard deviation for the number of adjusted points scored during each season, and the number of players who have been captain for a given number of seasons since they became a captain. Overall, this table provides the necessary background context for future longitudinal studies of the relationship between the performance during a season in which the player is a captain and the performance in future seasons (regardless of captain status).

The authors utilize a similar table to compare the pairwise correlations of six predictor variables (height, weight, position, the number of seasons played before becoming a captain for the first time, the age of a player at the time of his first captaincy, and the total number of times a player was a captain during his career) at the second level. The table checks for multicollinearity between the predictors and has a lower-triangular shape, with each predictor's mean and standard deviation values included as well. While units are not indicated within the table, the authors use footnotes to notify the reader that height is measured in inches, position is coded as 1 = defense and 0 = offense (the article says 1 = offense and 2 = defense, but we can treat 1 as the baseline category), and age is measured in years. A similar format is used to display the predictors of the hierarchical models. The first table in the results section splits the level one predictors into fixed and random effects, including the coefficient, standard error, degrees of freedom, and the test statistic for each row. Rather than including an additional column for the p-value, the researchers place asterisks next to the test statistics to denote which levels of significance the predictors satisfy.

If we were to edit the authors' EDA, we would provide more information in the tables and add visualizations that highlight the relationships between predictors at both levels. For example, while almost every predictor at the second level is quantitative, a player's position is categorical; thus, displaying the mean could be misleading. Instead, we would note that it is a categorical variable and add a frequency bar plot below the tables of position to make the breakdown of the predictor easier to comprehend. Additionally, we would include a bar plot of the proportion of players that are still captains for each of the seasons after initially being declared the captain. This plot would explicitly show the decrease in the number of players that remain a captain for every additional season. Furthermore, we would plot the effect of age (at the time of the first captaincy) on individual performance to examine the claim that aging was the key contributor to an overall negative trend in the multilevel model for captains.

If we could only add one graph to the article, we would plot a graph of seasons after one was designated captain on the x-axis and mean adjusted points for players that are and are not captains on the y-axis. This graph would focus on the longitudinal effect of being a captain for a prolonged period. Based on the comments made by the researchers in the "Performance Trends" section of the discussion, we hypothesize that we would see a downward trend for both current and noncurrent captains once seasons reach an undetermined number. Aspects to consider with this plot include the sample size for particular ages. For example, it is extremely rare for players younger than 25 or 26 to become a captain. In the unusual case of a young player becoming captain, we suspect that their talent and performances (e.g., exceptional adjusted points scored per season compared to players who become a captain for the first time later on in their careers) have an increasing performance trend for longer after they are designated captain compared to another player who was given the responsibility at the end of after their prime.

Limitations One major question presented in the article is how the results from the NHL data can be applied to other teams that may not necessarily be related to sports. The researchers combat this by citing several different studies that evaluated sociology and management using sports data, signifying that connecting conclusions to the was not a new revelation. Additionally, they make the argument that the role of a captain in hockey is more profound and significant than in basketball and football, which is why they felt it would be best to use hockey data specifically. Another notable limitation is the inability to evaluate the quality of leadership for a particular captain. One may argue that the quality of leadership can be evaluated through the team's success, but that relationship is significantly more complex. For example, a team may have an exceptional leader that performs extremely well, but if the team does not possess talent comparable to the rest of the league, then the team will most likely not be very successful. While the quality of leadership is subjective, the researchers argue that their study could be enhanced by evaluating which personal characteristics lead to great leaders, finding a way to quantify those values, and incorporating it into their original analysis.

Impact The authors claim that the study advances knowledge in two ways. On the practical front, the article's findings have implications for culture building, individual motivation, and role delegation. The authors theorize that one reason captaincy improves an individual's performance is because of a culture of leadership in the league. Since it is a highly respected position, this culture of respect improves a captain's performance. Thus, if organizations are to learn from this study, leaders must feel empowered and respected in order for their performance to improve. In turn, leaders must be capable of garnering the respect of their peers and subordinates.

Another factor the authors point to is one's motivation to lead. Because captaincy is so respected in the NHL, those who are offered the position are excited to take it. The benefits of leadership in the NHL outweigh the drawbacks. In other settings where this might not be the case, organizations must make positions of leadership appealing; otherwise, those who lead will not be motivated to do it well.

Ultimately, the authors outline three principles to ensure good leadership performance: ensure the leadership position is valued by the organization, ensure the leadership position is salient to the team, and ensure leadership responsibilities do not interfere with day-to-day responsibilities. These guidelines seem reasonable, especially since the authors specify that more research must be done on the causal linkage between these principles and effective leadership.

The second way this study advances knowledge is by further supporting the role accumulation perspective. This is an academic school of thought in which formal leadership is seen as a boon to performance because it gives leaders access to new resources and almost becomes a "self-fulfilling prophecy." Leadership status may give an individual a boost of confidence or make them more visible, presenting them with further opportunities. The findings of this article, written in 2004, still seem to ring true. NHL captaincy continues to be considered as one of the most important designations in sports, and NHL captains continue to be perceived as the heartbeat of their respective teams.

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