NFL Team Wins Per Season

January 16, 2020

Introduction: Statistical Analysis of Wins in the National Football League

American Football is one of the most popular and profitable sports in the United States. The Super Bowl alone is consistently the most-watched televised event every year and generates millions of dollars through commercials. The National Football League (NFL) brings in billions of dollars of revenue per year and cities and states ride and die in the hopes they place on their teams. The teams themselves are managed by the owners and front offices, but their flesh and blood are the players and coaches they are composed of. The performance of the players is measured through a seemingly enumerable amount of statistics the league keeps to track player and team progress and determine who is the best at any conceivable act on the football field.

The ultimate goal of every team in the NFL is to win the Super Bowl. To achieve this end a team must first make the playoffs and to make the playoffs they must achieve a certain number of wins relative to the other teams in their conference and their division. A team can make the playoffs in one of two ways: 1) have the most wins in their division (or be tied in wins in their division but have the advantage in the head to head encounters of the team they are tied with), or 2) clinch one of two wild-card spots which are earned by having the most wins once the division leaders are already established.

Using the team and player statistics that are taken over the course of a season, a model was created to predict the number of wins a team will achieve. The data used comes from the 2017 NFL season, in which the Philadelphia Eagles and the New England Patriots played in the Super Bowl, with the Eagles coming out on top as Super Bowl Champions. Many different variables that are recorded as statistics were used to construct the model, but in the end, the number of variables that proved to be significant was surprising. The methods, data, and analysis used to derive the final model will be explained thoroughly and conclusions will be given to provide possible explanations for why the model took the form it ultimately did.

Data Summary:

Dependent Variable

The goal of this analysis is to predict the number of wins a given team will achieve in a season based on certain factors. Hence, the dependent variable in question is regular-season wins. A team wins the game if their offense scores more points than the opposing team's offense at the end of regulation. If there is a tie at the end of regulation the game goes into overtime to decide the victor. If overtime commences and the score is still tied this results in both teams having a tie on their record. There were no ties in the 2017 season[(2)]. As a result, ties were not factored into the model.

In the regular season, each team plays 16 games. A good season is typically 10 or more wins, and likely to gain the team a spot in the playoffs. A 9 win season may still be enough to take a wild-card spot or win the division if the division in question is having a down year. Typically 8 or fewer wins will mean a team will miss the playoffs altogether. The model that was put together aims to predict the total wins in a season.

Independent Variables

1. The first random variable X_1 is the Margin of Victory (MoV). This measure takes into account the total amount of points scored over the season by a team, the total points allowed by the team's defense, and the total games played. Margin of Victory is calculated in the following manner:

$$\text{MoV} = \frac{\text{Points Scored - Points Allowed}}{\text{Games Played}}^{(1)}$$

This is an extremely important statistic because it compares the number of points a team scored against how many points the team allowed, and averaged it throughout the season. To win games a team must score more than their opponent and margin of victory is a comprehensive measure of just that.

2. One of the largest statistics both teams and individual players are evaluated on is yardage, which the random variables X_2 and X_3 are both measurements of. In football to score, the offense needs to bring the football into the end zone at the opposite end of the field (the defense can also score by taking the ball away from the opposing offense and taking it into the opposite end zone in a single play). The distance the ball travels on its path to the end zone is the yards gained. From the offensive perspective yards can be measured in two ways:

A. Passing yards, X_2: the yards gained when the quarterback throws the ball to one of his receivers, a catch is made, and the receiver takes the ball as far downfield as he can.

B. Rushing yards, X_3: the yards gained when an offensive player, normally a running back but sometimes the quarterback or a receiver, is handed off the ball and runs downfield to gain as many yards as they can.

3. X_4 is a measure of the quarterback rating (QBR). The quarterback position is generally the most important position on the team as the quarterback leads the offense, directs every offensive plays, and holds the most responsibility of any player. Having a good quarterback, such as Tom Brady who has won 5 Super Bowls with the Patriots, can be a large determining factor in the success a team has. This is why quarterbacks, on the whole, make the most money of any position. QBR is a system used to rate the passing ability of a team's quarterback(s) throughout the season. It takes into account the following four categories[2]:

A. Percentage of completions per attempt, Comp%$= (\frac{\text{Completions}}{\text{Attempts}} - 0.3) * 5$

B. Average yards gained per attempt, $\bar{\text{Yards}} = (\frac{\text{Yards}}{\text{Attempts}} - 3) * 0.25$

C. Percentage of touchdown passes per attempt, TD%$=(\frac{\text{Touchdown}}{\text{Attempts}}) * 20$

D. Percentage of interceptions per attempt, Int%$=2.375 - (\frac{\text{Interception}}{\text{Attempts}} * 25)$

QBR is then calculated in the following manner:

$$\text{QBR} = (\frac{\text{Comp\%} + \bar{\text{Yards}} + \text{TD\%} + \text{Int\%}}{6}) * 100$$

Where a perfect rating is a score of 158.3, and the minimum rating is 0[2].

4. X_5 is a measure of the experience of a team's offensive linemen. Offensive linemen do not get much of the spotlight, since they are not the ones making the plays, but they have an impact on every aspect of the offense. They need to protect the quarterback from the defense, and as such serve as an insurance policy for the on average highest investment a team has on a player in the quarterback. During pass plays, they need to hold off the defense to give the quarterback as much time as possible to make clean throws to the receivers. During rushing plays, they need to execute their blocking on the defensive players to make room for the running back so the running back has space to maneuver to take the ball downfield.

Since offensive linemen do not directly receive the ball it is more difficult to measure their performance. The random variable used for the offensive line in our model is a measure of the combined career starts for the two guards, two tackles, and center with the most starts in the current season[2].

5. X_6 measures the defensive ability of a team. On a given drive, the offense has four downs to take the ball ten yards. If they take the ball ten yards or more they receive a new set of four downs. If they do not make the ten yards, the ball switches possession to the other team. Many defensive statistics could be used to evaluate defensive performance, but the independent variable proposed in the model is the percentage of 3rd down attempts a defense allows. In the majority of cases, 3rd down is the down that determines if the ball will change possession, as fourth down is used most often to punt the ball farther down the field so the opposing offense has further to go to their end zone when they start with the ball. A defense that rarely gives up third downs, not only gets their offense the ball more often, but also can kill the momentum of the opposing team, and in critical situations this ability can be crucial to winning games. For example, in 2017 the Minnesota Vikings allowed only 25% of 3rd down conversions, and they went to the NFC championship game[(2)].

6. $D_{AE}, D_{AN}, D_{AS}, D_{AW}, D_{NE}, D_{NN}, D_{NN}, D_{NW}$ are dummy variables associated with each NFL division. There are two conferences in the NFL: the American Football Conference (AFC), and the National Football Conference (NFC). Each conference is divided into four divisions according to north, south, east, and west. Divisions play a large role in American football because each team plays every other team in their division twice every season. In the 16 game regular season, 6 of 16 games played by any team will be divisional games. This can make a large impact as seen with the 2017 AFC championship New England Patriots, who belong to the AFC East, which is typically one of the weakest divisions in the league.

Methods and Results

1. The proposed model to predict the number of wins a team will achieve in the NFL in a given season is

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6$$

$$+\beta_7 D_{AE} + \beta_8 D_{AN} + \beta_9 D_{AS} + \beta_{10} D_{AW} + \beta_{11} D_{NE} - \beta_{12} D_{NN} + \beta_{13} D_{NW} + \epsilon$$

$$\epsilon \text{ iid } \sim N(0, \sigma^2)$$

2. Using SPSS, the data for the 2017 season was used to estimate the model parameters, which produced the following model:

$$Y = 16.861 + 0.503X_1 - 0.001X_2 - 0.002X_3 + 0.016X_4 + 0.005X_5 - 11.057X_6$$

$$+0.922D_{AE} - 0.082D_{AN} + 0.184D_{AS} + 0.019D_{AW} + 0.322D_{NE} - 0.227D_{NN} + 1.127D_{NW}$$

Furthermore, the data produced F, R^2, $\bar{R^2}$, and S values of

$$F = 10.019, R^2 = 0.879, \bar{R^2} = 0.791, S = 1.46464$$

3. Testing significance of all parameters in the model using SPSS output

A. Significance of MoV
Ho: $\beta_1 = 0$ vs Ha: $\beta_1 \neq 0$
$\alpha = 0.05$
p-value< 0.001
$0.001 < 0.05 = \alpha \implies$ Reject Ho
There is enough evidence to reject Ho: $\beta_1 = 0$ at a 5% (and 1%) level of significance.

B. Significance of yards passing
Ho: $\beta_2 = 0$ vs Ha: $\beta_2 \neq 0$
$\alpha = 0.05$
test stat $t = -1.123$, p-value$= 0.276$
$0.276 > 0.05 = \alpha \implies$ Fail to Reject Ho
There is not enough evidence to reject Ho: $\beta_2 = 0$ at a 5% level of significance.

C. Significance of yards rushing
Ho: $\beta_3 = 0$ vs Ha: $\beta_3 \neq 0$
$\alpha = 0.05$
test stat $t = -1.072$, p-value= 0.0.298
$0.298 > 0.05 = \alpha \implies$ Fail to Reject Ho
There is not enough evidence to reject Ho: $\beta_3 = 0$ at a 5% level of significance.

D. Significance of QBR in model?
Ho: $\beta_4 = 0$ vs Ha: $\beta_4 \neq 0$
$\alpha = 0.05$
test stat $t = 0.264$, p-value= 0.795
$0.795 > 0.05 = \alpha \implies$ Fail to Reject Ho
There is not enough evidence to reject Ho: $\beta_4 = 0$ at a 5% level of significance.

E. Significance of OLExp
Ho: $\beta_5 = 0$ vs Ha: $\beta_5 \neq 0$
$\alpha = 0.05$
test stat $t = 1.306$, p-value= 0.208
$0.208 > 0.05 = \alpha \implies$ Fail to Reject Ho
There is not enough evidence to reject Ho: $\beta_5 = 0$ at a 5% level of significance.

F. Significance of allowed 3rd Down conversion % in model?
Ho: $\beta_6 = 0$ vs Ha: $\beta_6 \neq 0$
$\alpha = 0.05$
test stat $t = -1.444$, p-value= 0.166
$0.166 > 0.05 = \alpha \implies$ Fail to Reject Ho
There is not enough evidence to reject Ho: $\beta_6 = 0$ at a 5% level of significance.

G. Significance of Divisions in model
Ho: $Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \epsilon$ vs.
Ha: $Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 D_{AE} + \beta_8 D_{AN} + \beta_9 D_{AS} + \beta_{10} D_{AW} + \beta_{11} D_{NE} - \beta_{12} D_{NN} + \beta_{13} D_{NW} + \epsilon$
$\alpha = 0.05$
test stat: Partial F= 0.3375
CV=$F_{0.05}(7, 18) = 2.58$
$|F| < 2.58 \implies$ Fail to Reject Ho
There is not enough evidence to reject Ho: reduced model at a 5% level of significance.

4. Test reduced model with only statistically significant parameters against full model
Ho: $Y = \beta_0 + \beta_1 X_1 + \epsilon$ vs.
Ha: $Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 D_{AE} + \beta_8 D_{AN} + \beta_9 D_{AS} + \beta_{10} D_{AW} + \beta_{11} D_{NE} - \beta_{12} D_{NN} + \beta_{13} D_{NW} + \epsilon$
$\alpha = 0.05$
test stat: Partial F= 0.6553
CV=$F_{0.05}(12, 18) = 2.34$
$|F| < 2.34 \implies$ Fail to Reject Ho
There is not enough evidence to reject Ho: reduced model at a 5% level of significance.

5. Final proposed model based on parameter testing:

$$Y = 8.001 + 0.470X_1$$

with the following model values: $F = 141.929, R^2 = 0.826, \bar{R}^2 = 0.820, S = 1.36000$

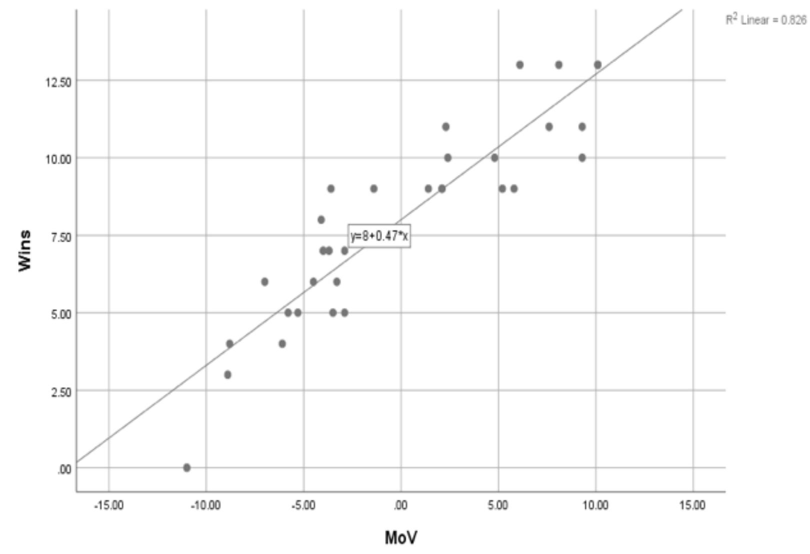

Figure 1: 2017 Margin of Victory against Team Wins

Testing model at 1% level of significance
Ho: $\beta_1 = 0$ vs. Ha: $\beta_1 \neq 0$
$\alpha = 0.01$
test stat $F = 141.929$
CV: $F_{0.01}(1, 30) = 7.56$
$|F| > 7.56 \implies$ Reject Ho
There is enough evidence to reject Ho: $\beta_1 = 0$ at a 1% level of significance $\implies$ model is adequate.

Conclusion:

Surprisingly, after testing and comparing all variables in the originally proposed model, only the Margin of Victory turned out to be a significant parameter at the 5% level, and the best model by far is the simple regression model with $Y = \beta_0 + \beta_1 X_1 + \epsilon$. Not only is the F value extremely large for this model, but the R^2 for the is 0.826 which signifies there is an 83% correlation between the number of wins and the Margin of Victory. Thinking logically about a team's season, it is necessary to score more points than the opposing team to win each game, and the larger the margin average is, would suggest a stronger likelihood that more victories will ensue. Also, looking at the constant term $\beta_0 = 8.001$ is logical since a team with a MoV=0, meaning they scored exactly as many points as they allowed, would rationally be expected to win exactly half their games, which is 8 games out of 16.

The data heavily supports the role of the Margin of Victory in team wins as well. Both the Philadelphia Eagles and New England Patriots won their respective conferences to go to the Super Bowl, and during the regular season, they achieved the same Margin of Victory of 10.1 and records of 13-3[1]. On the other side, the Cleveland Browns achieved a Margin of Victory of -11 and had the corresponding worst record in football at 0-16[1]. Overall Margin of Victory proved by far to be the best estimator and the best model is the simple linear regression model with Margin of Victory as its independent variable.

As for the rejected variables, some did have greater significance than others, proving they do have somewhat of an impact. The percentage of 3rd Downs allowed by a defensive had a p-value ≈ 0.17, showing that a team's defense ability to turn over on downs is a contributing factor to total wins, but not significant at the 5% level.

The next most significant variable was offensive line experience with a p-value ≈ 0.2. Since offensive linemen are so involved in whatever offensive scheme is run, it stands to reason that they do have some impact on the number of wins a team accrues. However, years of experience between the most often starting lineman on a team might not have been the best statistic to use to factor the offensive line into the model. Perhaps using another statistic, such as an offensive lineman rating, may prove to be more statistically significant.

Both yards passing and yards rushing had p-values ≈ 0.3, which again shows that they have some impact, but not enough to significantly affect the model. Also, the close p-value between yards rushing and yards passing suggests that there is not much of a difference between the impact passing vs. rushing yards have.

One of the most surprising results from running the model was the insignificance of QBR on team wins in a season, with a p-value ≈ 0.8. Quarterbacks are such a vital element in the game of football so it was not expected that this variable would matter so little to the model. However, QBR is a measure of the passing ability of a team's quarterback(s) throughout the season and therefore does not include other factors such as leadership, influence on team morale, and offensive play-calling ability. Therefore, while QBR may not be significant in the model, statistics that somehow incorporate other elements of what a quarterback contributes may well be better suited to be significant.

The division a team belongs to proved to be one of the least significant factors affecting wins. This was surprising as well since almost 40% of a team's games every year are within their division. This could suggest, however, that the NFL is at such a high level of competition that no matter what division a team belongs to, being good in one's division would also imply that the team would be considered good in comparison to the rest of the league, and therefore likely to get more wins.

On the whole, even though all independent variables but one proved to be insignificant, the final model that was settled on proved to be a good predictor of team wins with $R^2 = 0.826$. Like any sport, the human element will always play a factor and there will always be random factors that are impossible to predict. For further research into this model, more independent variables would need to be proposed that would prove to have more significance than those suggested. One independent variable that would likely have a large influence on the model would be the number of injuries of key players a team suffers throughout the season. American football is a very physical game, and injuries occur more often in the NFL than in any other professional sports league. There are many elements to take into consideration, which would include items such as the impact injured players have on the team when healthy, how long a player is out with injury (game(s) or rest of season), type of injury, etc. These would be difficult to compile into one statistic, but if managed could quite possibly be a determining factor on team wins. For now, though the best model to use is the simple linear regression model, with Margin of Victory as the independent variable.

References:

Two Websites were used for the compiling of data:

1. https://www.pro-football-reference.com/, which is a site that compiles team and player statistics for both the regular season and playoffs in every NFL season.

2. http://www.nfl.com/stats/team, which the official site of the NFL for team statistics and standings for the current season and all previous seasons.