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**Article**

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# Any given season?

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**Abstract.** An econometric analysis of the 2016 National Football League season is conducted with respect to regular season victories. Results obtained confirm many of the hypotheses made and bear much in common with one prior NFL study and several earlier MLB econometric analyses. Most of the data employed are fairly symmetric with relatively small standard deviations. Estimation results validate the importance of both defense and offense. Evidence is obtained that indicates that passing games are more important on offense, while shutting down the run matters most on defense. Beyond that, the regression equations also provide some insight to how human capital and payroll expenditures affect NFL regular season performances. The magnitudes of some coefficients and elasticities indicate that further analysis involving more explanatory variables can potentially provide additional clarity about what helps determine success in the NFL.
**Keywords.** National football league, Team performance.
**JEL.** M21, L20.

## 1. Introduction

The 2016 National Football League (NFL) season was full of memorable events. One of the most notable was the first out-of-state team relocation since 1997 as the former St. Louis Rams moved out of Missouri and returned to their former home in Los Angeles, California. The Rams had previously called Los Angeles home between 1946 and 1994, following an initial relocation from Cleveland, Ohio. The 2016 season also marked the last season for the Chargers in San Diego after playing after playing there 56 consecutive years. Interestingly, the Chargers are also headed to Los Angeles in 2017, the original site of the team when it was an American Football League charter member. Pre-game national anthem protests by San Francisco 49ers quarterback Colin Kaepernick and an appeals court reinstatement of New England Patriots quarterback Tom Brady from a "deflategate" suspension also occurred in 2016. Best of all, a lot of entertaining football was also played every Sunday (Anonymous, 2017, Fine, 2017).

What determined 2016 regular season success? To date, very few empirical analyses have been conducted for prior NFL seasons. It should be feasible, however, to carry out something similar to the Major League Baseball econometric

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studies that have been conducted in recent years (Fullerton *et al.*, 2014; Peach *et al.*, 2016). Such a study for the NFL may help identify what impacts teams' win-loss records. In addition, to investigate whether the labor market economic issues important in the baseball studies also influence organizational success in the NFL, team payroll data are included in the data sample (Fullerton & Peach, 2016).

The study is organized as follows. Section two provides an overview of previous studies related to this topic. Section three describes data and methodology. Section four summarizes estimation results. Final observations are offered in the concluding section.

## 2. Prior Studies

Hall of Fame Alabama football coach Bear Bryant stated that offense sells tickets, but defense is what really wins college championships (Dunnavant, 2005). In the NFL, great defense is also very important, but quarterbacks tend to receive the highest salaries (Gaines, 2016). So what aspect of the game influences on-field success the most? Clearly, any attempt to answer that question will require team data for both offense and defense. That is similar to baseball studies that reflect the importance of pitching, defense, and offense for achieving regular season success (Hakes & Sauer, 2006).

Some limited statistical analyses have also been completed using NFL data. Burke (2007) provides evidence that offense and defense contribute equally to obtaining regular season victories. Although fans have long argued that high powered offenses can outweigh weak defensive units, as well as the converse, this study was able to confirm and quantify those insights. It provides a logical starting point for an analysis of 2016 team effectiveness.

## 3. Data and Methodology

Data employed in the study are listed in Table 1. All of the variables are for the 2016 NFL regular season. WINS16, the number of regular season victories each team attained in 2016 is the variable of interest. Six on-field performance and two payroll variables are included in the sample. Those data are discussed below.

**Table 1.** *Variables, Descriptions, and Units*

| Variable | Descriptions and Units |
|---|---|
| WINS16 | 2016 regular season victories |
| YGPG16 | Total offensive yards gained per game |
| RYGPG16 | Offensive rushing yards gained per game |
| PYGPG16 | Offensive passing yards gained per game |
| YAPG16 | Total defensive yards allowed per game |
| RYAPG16 | Defensive rushing yards allowed per game |
| PYAPG16 | Defensive passing yards allowed per game |
| TPR16 | Total team payrolls expressed in millions of dollars |
| TPRSQ16 | Square of total team payroll in millions of dollars |

**Data Source**: [Retrieved from].

The six on-field performance ratios are reported on a per game basis. The on-field data include three offensive measures and three defensive measures. Offensive ability is approximated using total yards gained per game (YPG16), passing yards gained per game (PYPG16), and rushing yards gained per game (RYPG16). For defense, total yards allowed per game (YAPG16), passing yards allowed per game (PYAPG16), and rushing yards allowed per game (RYAPG6) are used. Those explanatory variables should allow examining the questions raised in Burke (2007).

Offensive and defensive statistics cover many, but probably not all, aspects of NFL organizational effectiveness. Collective salary payments for each roster (TPR16) are included as a measure of human capital for each organization. As player productivity increases, salaries tend to increase, and teams benefit, but that

is likely not an interminable process. To allow for the possibility of eventual negative returns associated with this variable, the square of total payrolls (TPRSQ16) is also included in the analysis.

Summary statistics for each of the variables in the sample are reported in Table 2. The average number of victories, WINS16, is 8. The highest number of wins was achieved by the New England Patriots with 14. The greatest level of futility was exhibited the Cleveland Browns with only 1 victory in 2016. WINS16 is slightly left-skewed and somewhat platykurtic.

On offense, NFL teams gained an average of 365 yards per game, YGPG16. The ageless arm of Drew Brees helped the New Orleans Saints post a league-high mark of 438 yards per game. At the other extreme, the Los Angeles Rams could only muster 285 yards per game. The distribution of YGPG 16 is highly symmetrical and leptokurtic as a consequence of the tight distribution of the data for this metric.

**Table 2.** *Summary Statistics*

| Variable | Mean | Std. Dev. | Max. | Min. | Skew. | Kurt. |
|---|---|---|---|---|---|---|
| WINS16 | 8.0 | 3.2 | 14 | 1 | -0.372 | 2.716 |
| YGPG16 | 365 | 30.9 | 438 | 285 | 0.188 | 4.098 |
| PYGPG16 | 256 | 30.4 | 329 | 198 | 0.219 | 3.176 |
| RYGPG16 | 109 | 18.4 | 164 | 75 | 0.874 | 5.117 |
| YAPG16 | 350 | 26.1 | 406 | 301 | 0.000 | 2.447 |
| PYAPG16 | 241 | 21.4 | 274 | 186 | -0.700 | 3.215 |
| RYAPG16 | 109 | 18.8 | 166 | 84 | 1.133 | 4.363 |
| TPR16 | $161.9 | $8.1 | $190.3 | $154.1 | 1.984 | 7.165 |

**Note:** Total team payroll data are in millions of dollars

Passing yards gained per game (PYGG16) has a mean of 256 yards per game in 2016. These data areare essentially symmetric and mesokurtic. In terms of yards gained per game, the New Orleans Saints dominates with a pass oriented offense and that propels this organization to topof the NFL. Quarterback inconsistency in San Francisco contributed to the poor performances of the 49ers with respect to both aerial yardage and victories.

Rushing yards per game (RYGPG16) in Table 2 has a mean of 109 with a standard deviation of 18.8. The skewness is positive and slightly right-tailed. A kurtosis statistic of 5.116 shows how leptokurtic is the distribution of this variable. The thundering ground game of Buffalo led the league, with the Minnesota Vikings trailed behind all of the other teams in this category.

Total yards allowed per game has a mean of 350 and a standard deviation of 26.1. These data are symmetric about the 350-yeard mean. Even though the standard deviation is relatively small, these data are still platykurtic. The Houston Texans allowed the fewest total yards per game in 2016. The San Francisco 49ers allowed the most total yards per game during the 2016 season.

Passing Yards allowed per game (PYAG16) has a mean of 241 yards per game. It is distributed very symmetrically and mesokurtically. Under the guidance of defensive coach Wade Phillips, the Denver Broncos allowed the fewest passing yards in the league. At the other end of the spectrum, New Orleans fared worse than any other in terms of yards allowed in the passing game.

Rushing Yards allowed per game (RYAPG16) has an average of 109 yards in Table 2.The distribution is right-tailed and leptokurtic. The majority of NFL teams that made the playoffs in 2016 had defenses that contained the run below the league mean. The Dallas Cowboys were the most successful at defensing against the run game in 2016, while the 49ers were least effective at this aspect of the game.

The average team payroll (TPR16) in the sample is just under $162 million. Aggregate salaries were highest for the Jacksonville Jaguars, Cleveland Brown,

San Francisco 49ers, and Tennessee Titans. Ironically, Jacksonville, Cleveland, and San Francisco also had the top three draft picks of the 2017 Draft. These three teams reflect the highest payrolls due to unused cap space and being able to apply it for the 2016 season. As shown in Table 2, team payroll data are right-skewed and strongly leptokurtic.

Two separate equation specifications are used in this study. Equation 1 is specified with the total offensive and defensive variables that do not distinguish between ground games and passing games. Arithmetic signs below each regressor indicate the hypothesized effect of each independent variable on WINS16. The parameters represent the marginal effects of the explanatory variables toward achieving victories. The subscript i = 1, 2, 3, ... 31, 32 is the numerical designation for each NFL organization.

$$WINS16_i = a_0 + a_1YGPG16_i + a_2YAPG16_i + b_3TPR16_i + b_4TPRSQ16_i \quad (1)$$
$$(+) \qquad (-) \qquad (+) \qquad (-)$$

In Equation 1, the number of wins should increase as teams gain more yards per game. The number of victories is hypothesized to decline as defenses surrender more yards per game. As noted above, the quadratic term included allows for potential negative returns that may eventually result with increased total payroll outlays.

Figures 1 and 2 help illustrate the intuition underlying the hypothesized signs for the on-field performance variables in Equation 1. The scatter plot in Figure 1 shows an easy to observe positive correlation between the dependent variable (WINS16) and the offensive yards gained per game independent variable (YGPG16). That is not a surprise since increases in offensive yards gained per game should be correlated with higher scores and better chances of victory. Of course, other variables also influence game results. The New Orleans Saints gained more offensive yards per game than any other team, but only won 7 contests.

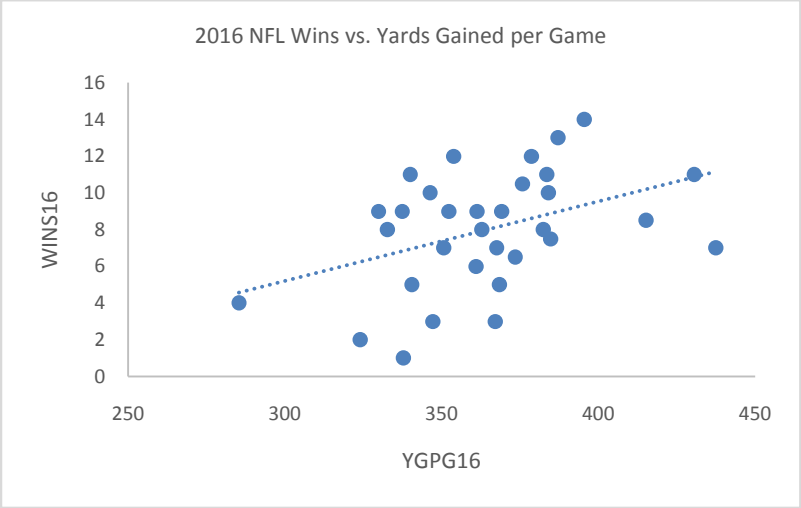


**Figure 1.** *2016 NFL Wins vs. Average Yards Gained per Game*

The scatter diagram Figure 2 displays the negative correlation between the dependent variable (WINS16) and the defensive yards allowed per game independent variable (YAPG16). Again, defense alone cannot guarantee victories. Despite losing J.J. Watts for most of the season, the Houston Texans still had a very stingy defense that allowed fewer yards per game than any other team. The Texans won a Division crown with 9 wins, but lagged behind other teams such as Kansas City or Oakland in terms of victories.

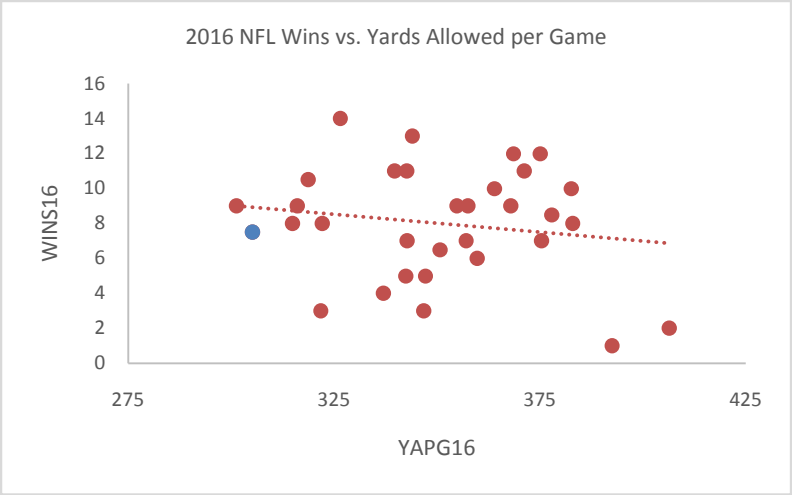


**Figure 2.** *2016 NFL Wins vs. Average Yards Allowed per Game*

Equation 2 provides a modified version of the basic specification by introducing rushing and passing yardage as separate regressors. Doing so allows for differential marginal effects of each explanatory variable on both sides of the ball. The hypothesized effect of each independent variable toward achieving victories is shown in the parenthetical signs below the equation.

$$WINS16_i = b_0 + \underset{(+)}{b_1 RYGPG16_i} + \underset{(+)}{b_2 PYGPG16_i} + \underset{(-)}{b_3 RYAPG16_i} +$$

$$+ \underset{(-)}{b_4 PYAPG16_i} + \underset{(+)}{b_5 TPR16_i} + \underset{(-)}{b_6 TPRSQ16_i} \qquad (2)$$

## 4. Empirical Results

Estimation results for Equation 1 are summarized in Table 3. All of the slope coefficients exhibit the hypothesized signs. The parameter estimate for YGPG16 indicates that for each 100 yards gained per game, five regular season wins are achieved. The parameter estimate for YAPG16 indicates that every additional 100 yards allowed per game by the defense, translates into six additional losses.

**Table 3.** *Equation 1 Estimation Results*

Dependent Variable: WINS16
Number of Observations: 32
Method: Least Squares with White Heteroscedasticity Consistent Covariance Matrix

| Explanatory Variable | Regression Coefficient | Standard Error | Computed t-Statistic | Prob. |
|---|---|---|---|---|
| Constant | -501.888 | 164.681 | -3.048 | 0.005 |
| YGPG16 | 0.047 | 0.012 | 4.041 | 0.000 |
| YAPG16 | -0.060 | 0.026 | -2.311 | 0.029 |
| TPR16 | 6.134 | 1.985 | 3.090 | 0.005 |
| TPRSQ16 | -0.018 | 0.006 | -3.166 | 0.004 |

| | | | |
|---|---|---|---|
| R-squared | 0.472 | Dep. Variable Mean | 8.000 |
| Adjusted R-squared | 0.394 | Dep. Variable Std. Dev. | 3.203 |
| Sum of squared Residuals | 167.733 | Std. Err. Regression | 2.492 |
| F-Statistic | 6.047 | F-Statistic Probability | 0.001 |
| Log Likelihood | -71.912 | | |

Both of the payroll coefficients are also statistically significant. Those parameters imply that negative returns will be associated with aggregate salaries in excess of $168.332 million. NFL teams that with payrolls greater than that amount in 2016 included the Cleveland Browns, the Jacksonville Jaguars, the San

Francisco 49ers, and the Tennessee Titans. The negative returns tipping point for team payrolls is calculated by taking the derivative of the estimated equation with respect to TPR16, setting that result equal to zero, and then solving for the TPR16 critical value.

Which on-field variable is more important, offense or defense? That question can be addressed by calculating standardized regression coefficients (Pindyck and Rubinfeld, 1998). In Table 4, the standardized coefficient calculations largely corroborate the Burke (2007) result that offense and defense are equally important in the NFL. In Table 4, the standardized offensive and defensive coefficient magnitudes are separated by less than one percentage point.

The elasticities are calculated by taking the first derivative of the equation with respect to each independent variable and then multiplying by the ratio of the mean that variable to the mean of the dependent variable (WINS16). The elasticities reported in Table 4 are very high. That potentially means that the specification may need to be amplified. Even in a league characterized by the "any given Sunday" slogan, such dramatically high sensitivities are somewhat suspicious.

**Table 4.** *Equation 1 Elasticities and Standardized Regression Coefficients*

| Variable | Elasticity | Standardized Coefficient |
|---|---|---|
| YGPG16 | 2.050 | 0.476 |
| YAPG16 | -2.609 | -0.485 |
| TPR16 | 4.758 | NC |

Of course, teams can run the ball or throw the ball. Which is more effective? Table 5 reports estimation results for Equation 2. Similar to the results above, all of the slope coefficients exhibit the expected signs. The computed t-statistic for pass defense, PYAPG16, does not satisfy the 5-percent significance criterion, but its magnitude seems reasonable. For payrolls, negative returns do not occur until teams breach the $168.117 million mark. That result is almost identical to the figure calculated for the payroll parameters in Table 3. Overall, the Equation 2 results shown in Table 5 are similar to those for Equation 1, but the Adjusted R-squared statistic is smaller in Table 5 than in Table 3.

**Table 5.** *Equation 2 Estimation Results*

Number of Observations: 32
Method: Least Squares with White Heteroscedasticity Consistent Covariance Matrix

| Explanatory Variable | Regression Coefficient | Standard Error | Computed t-Statistic | Prob. |
|---|---|---|---|---|
| Constant | -466.478 | 182.691 | -2.553 | 0.017 |
| RYGPG16 | 0.047 | 0.018 | 2.697 | 0.015 |
| PYGPG16 | 0.040 | 0.015 | 2.563 | 0.017 |
| RYAPG16 | -0.071 | 0.027 | -2.572 | 0.016 |
| PYAPG16 | -0.047 | 0.035 | -1.337 | 0.193 |
| TPR16 | 5.715 | 2.195 | 2.603 | 0.015 |
| TPRSQ16 | -0.017 | 0.006 | -2.669 | 0.013 |

| | | | |
|---|---|---|---|
| R-squared | 0.482 | Dep. Variable Mean | 8.000 |
| Adjusted R-squared | 0.358 | Dep. Variable Std. Dev. | 3.203 |
| Sum of squared Residuals | 164.719 | Std. Err. Regression | 2.567 |
| F-Statistic | 3.877 | F-Statistic Probability | 0.007 |
| Log Likelihood | -71.622 | | |

Table 6 reports elasticities and standardized coefficients for Equation 2. Most of the elasticity sizes in Table 6 are more plausible than those shown in Table 4. The one exception is the team payroll elasticity which still seems excessively large. The standardized coefficients have interesting magnitudes on each side of the ball. On offense, the passing game is noticeably more influential than the rushing game. On defense, stopping the run is found to be more important than shutting down the

passing game. Of course, it is not known whether those results hold in general or only for 2016, so more research on this topic may prove useful.

**Table 6.** *Equation 2 Elasticities and Standardized Regression Coefficients*

| Variable | Elasticity | Standardized Coefficient |
|---|---|---|
| RYGPG16 | 0.645 | 0.273 |
| PYGPG16 | 1.197 | 0.390 |
| RYAPG16 | -0.961 | -0.414 |
| PYAPG16 | -1.408 | -0.311 |
| TPR16 | 4.291 | NC |

## 5. Conclusion

This study attempts to carry out a "Sabernomics-style" analysis of NFL regular season victories. At least one prior effort indicates that offense and defense contribute equally toward winning on any given Sunday. This study examines whether those initial results for 2007 would be confirmed using regular season data for 2016. Two separate regression equations are estimated. To take into account human capital influences on roster success, both equations include team payroll data in a manner that allows for potential negative returns.

The econometric results are fairly interesting. In both cases, the results indicate that teams will probably not benefit very much from going past $168 million in aggregate player salaries. Beyond that, passing is found to be relatively more important than running the ball on offense. On defense, however, stopping the run is found to be more vital than grounding the opposing passing game.

The results obtained are based on only 32 observations for a single season. More research would definitely be worthwile. In additional to collecting data for other seasons, it may also be helpful to include additional variables that measure special teams effectiveness and other aspects of NFL on-field effectiveness. This initial study indicates, however, that it is feasible to quantify many aspects associated with regular season successes, even in a league where competitive surprises occur by design.

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# Appendix: Historical Data

| Team | WINS16 | YGPG16 | RYGPG16 | PYGPG16 |
|---|---|---|---|---|
| Arizona Cardinals | 7.5 | 385 | 108 | 277 |
| Atlanta Falcons | 11 | 431 | 121 | 310 |
| Baltimore Ravens | 8 | 363 | 91 | 271 |
| Buffalo Bills | 7 | 368 | 164 | 203 |
| Carolina Panthers | 6 | 361 | 113 | 248 |
| Chicago Bears | 3 | 367 | 108 | 259 |
| Cincinnati Bengals | 6.5 | 373 | 111 | 263 |
| Cleveland Browns | 1 | 338 | 107 | 231 |
| Dallas Cowboys | 13 | 387 | 150 | 237 |
| Denver Broncos | 9 | 337 | 93 | 245 |
| Detroit Lions | 9 | 352 | 82 | 270 |
| Green Bay Packers | 10 | 384 | 106 | 278 |
| Houston Texans | 9 | 330 | 116 | 214 |
| Indianapolis Colts | 8 | 382 | 102 | 281 |
| Jacksonville Jaguars | 3 | 347 | 102 | 245 |
| Kansas City Chiefs | 12 | 354 | 109 | 245 |
| Los Angeles Rams | 4 | 285 | 78 | 207 |
| Miami Dolphins | 10 | 346 | 114 | 232 |
| Minnesota Vikings | 8 | 333 | 75 | 257 |
| New England Patriots | 14 | 396 | 117 | 279 |
| New Orleans Saints | 7 | 438 | 109 | 329 |
| New York Giants | 11 | 340 | 88 | 252 |
| New York Jets | 5 | 340 | 113 | 228 |
| Oakland Raiders | 12 | 379 | 120 | 259 |
| Philadelphia Eagles | 7 | 351 | 113 | 237 |
| Pittsburgh Steelers | 11 | 384 | 110 | 274 |
| San Diego Chargers | 5 | 369 | 94 | 274 |
| San Francisco 49ers | 2 | 324 | 126 | 198 |
| Seattle Seahawks | 10.5 | 376 | 99 | 276 |
| Tampa Bay Buccaneers | 9 | 361 | 101 | 260 |
| Tennessee Titans | 9 | 369 | 137 | 233 |
| Washington Redskins | 8.5 | 415 | 106 | 309 |

**Notes:** WINS16 = 2016 Regular Season Victories; YGPG16 = 2016 Offensive Yards Gained per Game; RYGPG16 = 2016 Offensive Rushing Yards Gained per Game; PYGPG16 = 2016 Offensive Passing yards Gained per Game

| Team | YAPG16 | RYAPG16 | PYAPG16 | TPR16 |
|---|---|---|---|---|
| Arizona Cardinals | 305 | 95 | 210 | $158.968416 |
| Atlanta Falcons | 371 | 105 | 267 | $158.801671 |
| Baltimore Ravens | 322 | 89 | 233 | $155.178755 |
| Buffalo Bills | 357 | 133 | 224 | $157.495431 |
| Carolina Panthers | 360 | 92 | 268 | $157.993141 |
| Chicago Bears | 347 | 122 | 225 | $156.588879 |
| Cincinnati Bengals | 351 | 113 | 238 | $162.677552 |
| Cleveland Browns | 392 | 143 | 250 | $176.686294 |
| Dallas Cowboys | 344 | 84 | 260 | $159.261183 |
| Denver Broncos | 316 | 130 | 186 | $154.095041 |
| Detroit Lions | 355 | 106 | 248 | $158.591216 |
| Green Bay Packers | 364 | 95 | 269 | $163.439289 |
| Houston Texans | 301 | 100 | 202 | $157.186080 |
| Indianapolis Colts | 383 | 120 | 263 | $160.609029 |
| Jacksonville Jaguars | 322 | 106 | 215 | $190.301710 |
| Kansas City Chiefs | 369 | 121 | 247 | $157.955930 |
| Los Angeles Rams | 337 | 104 | 233 | $155.665189 |
| Miami Dolphins | 383 | 140 | 242 | $166.767319 |
| Minnesota Vikings | 315 | 107 | 208 | $156.914717 |
| New England Patriots | 326 | 89 | 238 | $159.642451 |
| New Orleans Saints | 375 | 102 | 274 | $155.562062 |
| New York Giants | 340 | 89 | 251 | $167.320159 |
| New York Jets | 342 | 99 | 244 | $157.528734 |
| Oakland Raiders | 375 | 118 | 258 | $168.332753 |
| Philadelphia Eagles | 343 | 103 | 240 | $161.570362 |
| Pittsburgh Steelers | 343 | 100 | 243 | $157.628978 |
| San Diego Chargers | 347 | 98 | 249 | $156.774767 |
| San Francisco 49ers | 406 | 166 | 241 | $176.591934 |
| Seattle Seahawks | 319 | 93 | 226 | $154.522927 |
| Tampa Bay Buccaneers | 368 | 117 | 251 | $161.138366 |
| Tennessee Titans | 358 | 88 | 269 | $176.357826 |
| Washington Redskins | 378 | 120 | 258 | $161.964024 |

**Notes:** YAPG16 = 2016 Defensive Yards Allowed per Game; RYAPG16 = 2016 Defensive Rushing Yards Allowed per Game; PYAPG16 = 2016 Defensive Passing yards Allowed per Game; TPR16 = 2016 Total Team Payroll in Millions of US$

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