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Salary Distribution and Winning Percentage: A Panel Data Analysis of the National Football League

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HONORS THESIS

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Table of Contents

ABSTRACT

This paper analyzes the effect of player salary distribution, as well as other external and internal factors, on regular season win percentage of teams in the National Football League (NFL) over the past four seasons. The conclusions from this study were drawn from regression analysis of NFL salary data over the past four seasons (2019-2023). Player salaries were collected and condensed into twenty independent variables. These independent variables along with 8 control variables were regressed against regular season win percentage. The results indicate the greater total expenditure, a greater salary spread (range and variance), and greater salaries for the highest and lowest earning players are positively correlated with regular season win percentage.

INTRODUCTION

In professional sports, the primary goal for any individual franchise is to maximize the team's performance and have the most success possible. "Fame and fortune" are the rewards for teams that have much success and win championships within their respective sports. It is a common assumption that the team which spends the most money to acquire the most player talent will have the most success. However, how does the actual distribution of this salary expenditure impact a team's success during the regular season? This research seeks to reveal the impact of a range of salary distribution decisions on a National Football League (NFL) team's regular season winning percentage. It also aims to highlight which salary distribution decisions play the largest role in improving a team's level of success during the season.

For example, out of the twenty-five highest paid players in the National Football League, twenty-one of them play on the offensive side of the ball (Camenker, 2022). Do the teams with the highest paid offensive players have the most success? Should a larger financial investment be made on the defensive side of the ball? Or, perhaps, is it more effective to distribute salaries more evenly across an entire team?

In 2022, Quarterback Aaron Rodgers was one of the highest paid players in the league, earning a large salary from the Green Bay Packers. In that same year, the Packers had eight wins, nine losses, and did not make it to the postseason. This was not a successful season at all by NFL standards. Conversely, Quarterback Patrick Mahomes was also one of the NFL's top earners that year. Mahomes and the Kansas City Chiefs had a season that was marked by fourteen wins and three losses, making the Chiefs the best team in the American Football Conference (AFC) heading into the playoffs. Furthermore, the Chiefs would go on to win the Super Bowl that year defeating the Philadelphia Eagles from the National Football Conference (NFC) (NFL.com). Thus, what impact did the structure and composition of the teams' salary expenditure have on the wildly different results of their seasons respectively?

Additionally, the four highest paid players of the 2022 season that played on the defensive side of the ball were Aaron Donald (Los Angeles Rams), TJ Watt (Pittsburgh Steelers), Joey Bosa (Los Angeles Chargers), and Myles Garrett (Cleveland Browns). Interestingly, of these

teams, only the Chargers made it to the postseason and were promptly eliminated in the first round. The Browns, Rams, and Steelers did not make the postseason at all (NFL.com). Therefore, was it a mistake of these teams to invest in their defensive talent? Or was it perhaps other salary expenditure decisions that lead to their teams' poor performance?

Using salary data for 2019-2023, this study will examine the impact of the structure and composition of an NFL team's payroll expenditure on its winning percentage in the regular season. A greater regular season winning percentage has many financial and competitive advantages for an NFL team, including increased ticket and apparel sales and the opportunity to play at home in the post-season. The conclusions from this study will highlight the variables that have the biggest impact on improving team success in the regular season and can have significant real-world applications in informing payroll and administrative decisions by NFL owners, coaches, and managers.

LITERATURE REVIEW

With regards to payroll expenditure, the literature seems to suggest that the amount, structure, and composition of a professional sports franchise's payroll can have a positive impact on the team's performance and success. A study by Cyrenne (2018) drew the conclusion that higher relative team payroll totals and a larger maximum salary are positively related with a team's winning percentage. In other words, higher salaries and increased total expenditure on payroll can increase a team's success in a given season. Furthermore, a related study of the NCAA by Jones (2013) drew the conclusion that within Division 1 athletics (among FBS programs), expenditures on athletics were positively correlated with team performance and success. In addition, a study about Major League Baseball by Schwartz and Zarrow (2009) concluded that the ability to spend money on top-tier talent diminishes some elements of competitive balance within the league and was correlated positively with regular season winning percentage. Simply put, the ability to increase payroll spending on "top-tier" talent had positive outcomes in improving a team's winning percentage. Borghesi (2008) argues that team success is a function of both the actual and perceived equity of player salaries. That is, the fairness of a team's pay structure for the players plays a role in team success. Yet, the

literature seems to be somewhat divided on how the structure of the payroll impacts team performance success. Mondello and Maxcy (2009) assert that on-field performance is improved when player salaries are more equitable across teams, while another researcher argues that the acquisition of a handful of elite players is more effective than the acquisition of many good players (Zimmer, 2016). This means that the literature is divided on whether having salary equity across an individual team will lead to increased success on the field and an increased winning percentage.

However, some researchers assert that decreased salary inequality may yield positive outcomes relating to team success. In a payroll and salary investigation into Major League Soccer (MLS), Coates et al. (2016) found that salary inequality across a team was negatively correlated with team success. In other words, greater inequality in team salaries could have a negative effect on team success. Although this study investigates Major League Soccer and not the National Football League, the study, similar to Mondello and Maxcy, found that reduced salary inequality was more effective in producing positive outcomes in terms of team success. Additionally, a study of four professional sports, the NBA, NFL, NHL, and MLB, by Shorin (2017) found that the National Football League had the highest competitive balance and showed the weakest correlations of several variables and success measurements. In other words, the researcher found that payroll expenditure and other variables had a weaker effect on winning percentage and other success measurements in the NFL than in other professional sports leagues.

The impact of alternative factors relating to a team's success has also been widely researched and explored. A variety of external and internal factors can impact an NFL team's success. For example, improved on-field performance can significantly increase win percentage. Arkes (2011) found that NFL coaches and teams can have greater success by controlling the passing game both on the offensive and defensive side of the ball. In other words, team success can be improved by increasing passing success on offense and reducing passing success on defense. Conversely, Zhang et al. (2017) found that increasing rushing attempts was strongly associated with improved success. Ultimately, the literature suggests that

improved performance both on the offensive and defensive side of the ball is positively associated with team success.

The literature surrounding this area of research explains that payroll spending and structure, which has a very significant impact, along with a variety of alternative factors play a role in the success that a professional sports team has. The variables and results explored in the previous research will play a vital role in helping to guide and inform this investigation about the isolated impact of payroll structure and expenditure on an NFL team's winning percentage from 2019-2023. For example, for NFL managers and owners, the literature suggests that the amount and structure of the payroll may play an important role in guiding success. The consensus of the literature surrounding payroll organization is that increased payrolls are positively correlated with improved team success. The key takeaway from the research as a whole is that the success of a professional sports team is based on numerous external and internal factors, and that payroll expenditure and structure can have a significant impact.

METHODOLOGY

Based on the literature, a number of regression models were built to explore and analyze the relationship between salary expenditure and win percentage. The number of the model corresponds with the number in the regression results table (See Results section).

(Model 1)

$$WinPct_{it} = \beta_0 + \beta_1 lnTotalExpenditure_{it} + \varepsilon_{it}$$

(Model 2)

$$WinPct_{it} = \beta_0 + \beta_1 lnTotalOffenseExpenditure_{it} + \beta_2 lnTotalDefenseExpenditure_{it} + \beta_3 lnTotalSpecialTeamsExpenditure_{it} + \varepsilon_{it}$$

(Model 3)

$$WinPct_{it} = \beta_0 + \beta_1 lnTotalSalaryVariance_{it} + \varepsilon_{it}$$

(Model 4)

$$WinPct_{it} = \beta_0 + \beta_1 lnOffenseSalaryVariance_{it} + \beta_2 lnDefenseSalaryVariance_{it}$$
$$+ \beta_3 lnSpecialTeamsSalaryVariance_{it} + \varepsilon_{it}$$

(Model 5)

$$WinPct_{it} = \beta_0 + \beta_1 lnTotalSalaryRange_{it} + \varepsilon_{it}$$

(Model 6)

$$WinPct_{it} = \beta_0 + \beta_1 lnOffenseSalaryRange_{it} + \beta_2 lnDefenseSalaryRange_{it}$$
$$+ \beta_3 lnSpecialTeamsSalaryRange_{it} + \varepsilon_{it}$$

(Model 7)

$$WinPct_{it} = \beta_0 + \beta_1 lnHighestTotalSalary_{it} + \varepsilon_{it}$$

(Model 8)

$$WinPct_{it} = \beta_0 + \beta_1 lnHighestOffenseSalary_{it} + \beta_2 lnHighestDefenseSalary_{it}$$
$$+ \beta_3 lnHighestSpecialTeamsSalary_{it} + \varepsilon_{it}$$

(Model 9)

$$WinPct_{it} = \beta_0 + \beta_1 lnLowestTotalSalary_{it} + \varepsilon_{it}$$

(Model 10)

$$WinPct_{it} = \beta_0 + \beta_1 lnLowestOffenseSalary_{it} + \beta_2 lnLowestDefenseSalary_{it}$$
$$+ \beta_3 lnLowestSpecialTeamsSalary_{it} + \varepsilon_{it}$$

In each model, a distinct measure or multiple measures of expenditure are included. In model 1, total salary expenditure is used as the expenditure measure. For model 2, total salary expenditure is broken down by offense, defense, and special teams. These are each used as expenditure measures respectively and run as a single regression. In model 3, the total salary variance is used. Model 4 uses offense, defense, and special teams variance as the expenditure measures. In model 5, the team's total salary range is the expenditure measure. Model 6 regresses the offense, defense, and special teams ranges against win percentage. In model 7, the highest overall salary serves as the expenditure measure. The highest offense,

defense, and special teams' salaries are used as expenditure measures in Model 8. Conversely, Model 9 uses the lowest overall salary as the expenditure measures. Again, the lowest offense, defense, and special teams' salaries are used in Model 10.

Eight control variables were used in the regressions as well. These variables were used to control for on-field performance and were meant to isolate the effects of the expenditure variables. The offensive control variables used were passing yards, rushing yards, turnovers, and points earned. Conversely, the defensive control variables were passing yards, rushing yards, turnovers, and points given up.

Each of the ten regressions were run once without the control variables and once with the control variables. However, all of the regressions were run using time fixed effects. This means that the results of the regressions controlled for changes over time from 2019-2023. Additionally, all models were using ordinary least squares (OLS) regression estimation techniques.

DATA

The data for this study was collected from two different sources. The win percentage variable as well as the control variables were collected from the Pro Football Reference website (Pro-football-reference.com). The player salary data was collected from the Spotrac website, which tracks player salaries by year across several professional sports (Spotrac.com).

Table 1
Summary Statistics

Variable	Observations	Mean	Standard Deviation	Minimum	Maximum
Win Percentage	128	0.4979	0.1926	0.625	0.875
Total Expenditure	128	1.37e+08	2.75e+07	6.09e+07	2.00e+08
Offense Expenditure	128	7.01e+07	1.76e+07	2.76e+07	1.11e+08
Defense Expenditure	128	6.28e+07	1.63e+07	2.02e+07	1.04e+08
Special Teams Expenditure	128	4543812	2019148	1460881	1.02e+07

Total Variance	128	1.44e+13	7.19e+12	2.86e+12	4.37e+13
Offense Variance	128	1.78e+13	1.17e+13	1.30e+12	5.70e+13
Defense Variance	128	1.26e+13	8.55e+12	5.98e+11	4.77e+13
Special Teams Variance	128	1.63e+12	1.75e+12	1.51e+09	6.88e+12
Total Range	128	1.85e+07	6140341	8295392	3.55e+07
Offense Range	128	1.66e+07	6838673	5037461	3.51e+07
Defense Range	128	1.39e+07	5189551	3013334	3.15e+07
Special Teams Range	128	1979902	1296385	70000	5055882
Highest Total Salary	128	1.86e+07	6162908	8333333	3.58e+07
Highest Offense Salary	128	1.67e+07	6834414	5083294	3.58e+07
Highest Defense Salary	128	1.41e+07	5220962	3050000	3.23e+07
Highest Special Teams Salary	128	2639153	1367864	570000	5570000
Lowest Total Salary	128	81309.29	95411.51	29118	769444
Lowest Offense Salary	128	142267.3	177722.9	29118	811244
Lowest Defense Salary	128	145588.4	156224.8	29118	769444
Lowest Special Teams Salary	128	659251.4	298918.8	36666	1250834
Passing Yards (For)	128	3796.086	562.7898	2219	5229
Passing Yards (Against)	128	3796.086	417.3123	2707	4742
Rushing Yards (For)	128	1931.734	382.9279	1156	3296
Rushing Yards (Against)	128	1931.734	320.0127	1181	2894
Turnovers (For)	128	21.8125	5.226748	9	38
Turnovers (Against)	128	21.8125	5.217702	8	41
Points (For)	128	380.7344	69.14204	243	531
Points (Against)	128	380.7344	56.08549	225	519

Over the past four seasons, the average regular season win percentage was 0.4979. Furthermore, the average offensive salary expenditure was slightly greater than the average defensive salary expenditure. The offensive side of the ball also had a greater average range, variance, and highest total salary. The defensive side of the ball had a greater average lowest total salary.
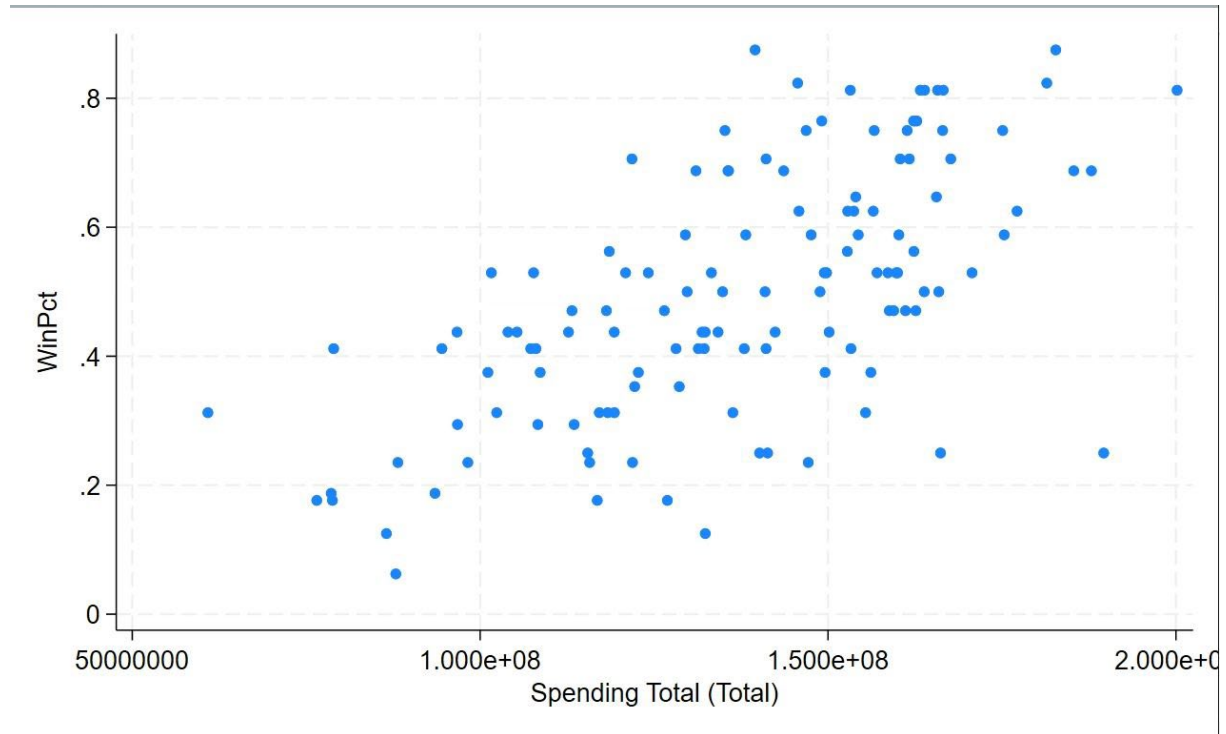
Figure 1

Winning Percentage and Total Salary Expenditure

Figure 1 shows the relationship between a team's total salary expenditure and regular season win percentage over the past four seasons.

This graph shows the relationship between Total Salary Expenditure and Win Percentage over the past four seasons. It is evident that these two variables show a strong positive correlation. Given the size difference between the two variables, the expenditure variable was log-transformed for the regression analysis.

Figure 2

Winning Percentage and Total Salary Variance

Figure 2 shows the relationship between a team's total salary variance and regular season win percentage over the past four seasons.

This graph shows the relationship between Total Salary Variance and Win Percentage over the past four seasons. It is evident that these two variables demonstrate a weakly positive correlation. Given the size difference between the two variables, the expenditure variable was log-transformed for the regression analysis.
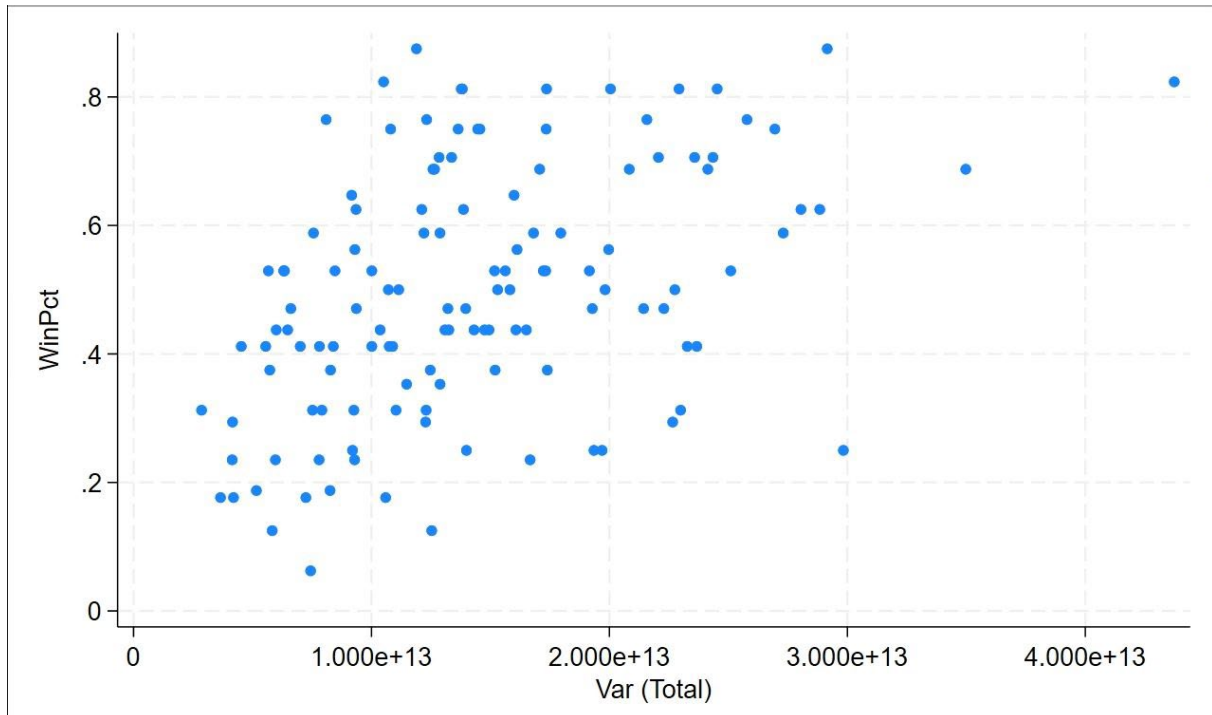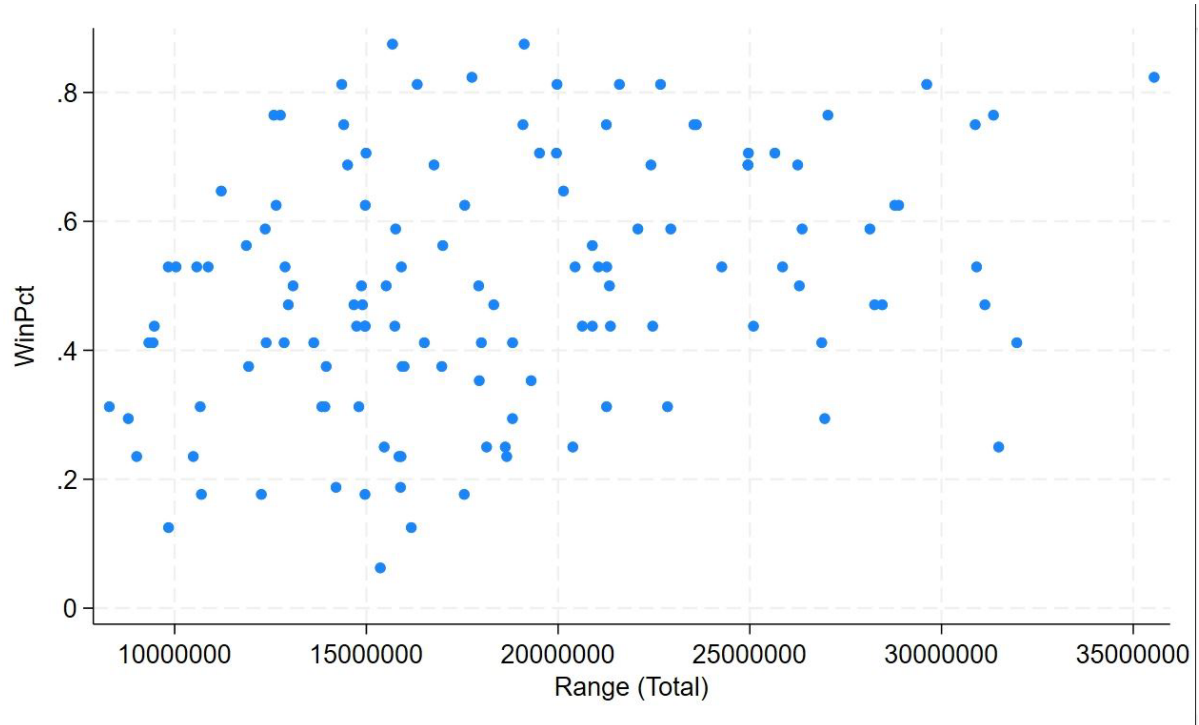
Figure 3

Winning Percentage and Total Salary Range

Figure 3 shows the relationship between a team's total salary range and regular season win percentage over the past four seasons.

This graph shows the relationship between Total Salary Range and Win Percentage over the past four seasons. It is evident that there is no strong correlation between these two variables. Given the size difference between the two variables, the expenditure variable was log-transformed for the regression analysis.

RESULTS

Each of the ten regressions were run once without the control variables and once with the control variables. The numbers in the table correspond to the number of the model that was run. The regression results are presented in Table 2.

Table 2

Table 2 shows the regression results for Model 1 through Model 4. These regressions were run without the control variables.

Variable	1	2	Variable	3	4
Dependent Variable: Win Percentage					
lnTotal Sal	0.5572*** (0.0623)		lnTotal Sal Var	0.1778*** (0.0296)	
lnTotal Off Sal		0.2106*** (0.0528)	lnOff Sal Var		0.0855*** (0.0207)
lnTotal Def Sal		0.3022*** (0.0513)	lnDef Sal Var		0.0824*** (0.0218)
lnTotal ST Sal		0.3022*** (0.0513)	lnST Sal Var		0.0112 (0.0075)
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes
Controls	No	No	No	No	No

The results from these regressions suggest that total expenditure, offense expenditure, defense expenditure, and special teams' expenditure are positively correlated with win percentage and were found to be statistically significant at a 99% significance level. Additionally, total salary variance, offensive salary variance, and defensive salary variance were positively correlated with win percentage and were found to be statistically significant at 99% significance level. Special Teams' salary variance was found to be statistically insignificant.

Table 3

Table 3 shows the regression results for Model 5 through Model 10. These regressions were run without the control variables.

Variable	5	6	Variable	7	8	Variable	9	10
Dependent Variable: Win Percentage								
lnTotal Sal Range	0.1919*** (0.0492)		lnHigh Sal Total	0.1942*** (0.0492)		lnLow Sal Total	0.0937*** (0.0238)	
lnOff Sal Range		0.1207*** (0.0374)	lnHigh Sal (Off)		0.1220*** (0.0374)	lnLow Sal (Off)		0.0463** (0.0183)
lnDef Sal Range		0.0990** (0.0423)	lnHigh Sal (Def)		0.0992** (0.0423)	lnLow Sal (Def)		0.0728*** (0.0190)
lnST Sal Range		0.0203 (0.0161)	lnHigh Sal (ST)		0.0487* (0.0269)	lnLow Sal (ST)		0.0120 (0.0216)
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	No	No	No	No	No	No	No

The results from these regressions suggest that total salary range as well as offense and defense salary range are positively correlated with win percentage and found to be statistically

significant. Furthermore, the highest total salary as well as the highest offense, defense, and special teams' salaries were also found to be positively correlated and statistically significant. Additionally, the lowest salaries for the whole team, offense, and defense were positively correlated and statistically significant as well.

Table 4

Table 4 shows the regression results for Model 1 through Model 4. These regressions were run with the control variables.

Variable	1	2	Variable	3	4
Dependent Variable: Win Percentage					
lnTotal Sal	0.1090** (0.0494)		lnTotal Sal Var	0.0388** (0.0172)	
lnTotal Off Sal		0.0360 (0.0343)	lnOff Sal Var		0.0213* (0.0117)
lnTotal Def Sal		0.0760** (0.0360)	lnDef Sal Var		0.0154 (0.0121)
lnTotal ST Sal		0.0152 (0.0170)	lnST Sal Var		0.0031 (0.0039)
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes

These regression results suggest that total salary expenditure and defense salary expenditure are positively correlated with win percentage and statistically significant at a 95% significance level. Furthermore, total salary variance and offense salary variance were positively correlated with win percentage and significant at 95% and 90% significance level respectively. All other variables were found to be statistically insignificant.

Table 5

Table 5 shows the regression results for Model 5 through Model 10. These regressions were run with the control variables.

Variable	5	6	Variable	7	8	Variable	9	10
Dependent Variable: Win Percentage								
lnTotal Sal Range	0.0446* (0.0249)		lnHigh Sal Total	0.0450* (0.0249)		lnLow Sal Total	0.0193 (0.0122)	
lnOff Sal Range		0.0310 (0.0194)	lnHigh Sal (Off)		0.0311 (0.0196)	lnLow Sal (Off)		-0.0008 (0.0094)
lnDef Sal Range		0.0107 (0.0213)	lnHigh Sal (Def)		0.0109 (0.0214)	lnLow Sal (Def)		0.0258*** (0.0097)
lnST Sal Range		0.0052 (0.0080)	lnHigh Sal (ST)		0.0127 (0.0136)	lnLow Sal (ST)		0.0029 (0.0109)
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Based on the results of these regressions, total salary range and the highest total salary are positively correlated with win percentage and statistically significant at a 90% significance level. Additionally, the lowest defense salary was also positively correlated with win percentage and statistically significant at a 99% significance level. All other variables were found to be statistically insignificant.

CONCLUSIONS

These results lead to some interesting conclusions. First, greater salary expenditure in general can have a positive impact on win percentage. This makes sense as, generally, greater expenditure indicates the acquisition of more talented players by the given team. Additionally, the results of the data suggest that increasing salary expenditure on defensive players can also help to improve a team's win percentage within the regular season. This is an unexpected finding to some degree. Many people might argue that increasing expenditure on the offense rather than the defense would be more effective in improving success. However, the results of the data indicate that defensive expenditure had a more significant impact on improving win percentage than offensive expenditure.

The results also indicate a positive correlation between total salary variance as well as the offense's salary variance and win percentage. There was also found to be a positive correlation between the total range of salaries and win percentage. Increasing the largest single salary on the team was also positively associated with greater success. These results suggest that increasing the spread of salaries across a team was strongly linked with a greater regular season win percentage during the study period. In other words, dedicating a larger portion of the team's total salary expenditure to the highest earning players has proven to be beneficial over the past four seasons. This aligns with the conclusions drawn in much of the research included in the literature review. Research in this area generally argues that high salary concentration and low levels of salary dispersion have been correlated with greater success. Finally, one interesting finding of the analysis was the positive and significant correlation between the smallest defense salary and win percentage. The results suggest that increasing the smallest single salary on the defensive side of the ball could prove to be

effective. One may not assume that the salaries of the lowest-paid players would have a significant impact on team success. Furthermore, it is interesting that only the lowest salaries on defense had a significant impact, not on the offense or even on the entire team. Ultimately, NFL coaches, owners, and managers can structure their team's compensation using these results to achieve the greatest possible regular season win percentage considering all other factors.

However, there are several limitations to the results and conclusions of this study. First, the data only includes the 2019/2020-2022/2023 seasons and does not include the most recent 2023/2024 season. It is possible that potential changes in the structure of salary expenditure across NFL teams in the most recent season could impact the overall results of the study. Additionally, the win percentages only include wins and losses in the regular season, excluding pre-season and post-season games. Future research could help to uncover the impact of different salary structure variables on post-season performance and championship attainment. Furthermore, the player salaries used in this study were their total cap space hit to the team, including base salary, signing bonuses, performance bonuses, etc. Further research could both investigate the impact of the isolated base salary and/or explore the impact and effectiveness of different salary bonuses on team success.

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