The Impact of NFL Salary Cap Concentration on Team Success

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Abstract

The paper empirically tests National League Football (NFL) team data from 2000 through 2009 to ascertain factors of team performance. Of particular interest is the assessment of payroll distribution on team performance. The results indicate that the salary concentration has a non-linear influence on team performance. Success in the NFL can be best achieved at either extreme of low or high salary concentrations. A threshold of team talent must be assembled before on field success is achieved. Acquiring elite talent, especially at the quarterback position, is likely the best alternative to achieve high levels of team performance. It is further shown that larger markets have a positive performance bias which suggests an ability to more easily acquire better player talent. The results indicate that NFL salary distribution has an impact on team success, and that it is preferable to acquire fewer elite players than many good players.

Keywords: National Football League (NFL), Winning, Salary, Salary Cap, Sports Marketing
Introduction

The National Football League (NFL) is one of numerous professional sports leagues in the United States which employ salary restrictions on individual teams. The salary restriction (salary cap) is calculated using a percentage of total revenues generated by the league in a given year. The salary cap was initiated during the 1994 season, and the details are negotiated as part of the collective bargaining agreement (CBA) between the players union and league ownership. The details of the salary cap are re-negotiated with each renewal of the CBA. As part of the agreement, teams have a yearly maximum which they can spend on player salaries (with defined exceptions) and a spending floor.

Under the salary cap system, teams are afforded the discretionary ability to spend similar sized pools of money in any manner they desire, which allows for cross comparisons. A team selects its players and pays them from available salary cap funds. The study focuses on salary distribution across a team’s roster of approximately 50 players to determine if allocation decisions and level of salary concentration can influence success in the NFL.

Literature Review

The salary cap system provides teams with access to nearly identical pools of funds in which to pay their players. A competitive advantage can be achieved if some teams are better able assess player talent relative to other teams. Attempts to identify such statistical value in players began in earnest following the publication of Bill James (1985) analysis of Major League Baseball (MLB) players and the topic’s subsequent notoriety in popular culture (Lewis, 2003). The lessons of Bill James’ sabermetric approaches in determining player value in baseball have since been modified and adopted in varying degrees by most sports in an attempt to gain competitive edge. Rather than following similar steps, this paper examines the distribution of these salary cap funds from an aggregated viewpoint to determine if an optimal distribution of salary cap can be found.

Seminal works examining distributional issues of salaries began with Lazear and Rosen (1981) who theorize that a wide variation in sport salaries is an incentive to higher productivity. This idea is forwarded by Rosen (1981) who observes the “superstar” effect and that wide variation in salaries is important in team success. Simmons and Berri (2011) examine the salary structure of the National Basketball Association (NBA) and also conclude that increased pay inequality enhances player performance and increases the probability of success. However, this research of pay inequality in sports is not uniformly consistent. Research by Akerlof and Yellen
(1985) find that salaries with a narrow distribution lead to success in sports where cooperation is required. Katayama and Nuch (2011) in examining game level NBA data find no link between team performance and salary distribution.

Rather than finding a unique distribution common to all sports, it is possible the optimal salary distribution is sport dependent. As the conditions, rules, and objectives of each sport vary, an optimal distribution can be unique to each sport. Einolf (2004) compares the salary structure of the NFL with MLB. While the NFL uses a relatively hard salary cap, MLB employs only modest salary restrictions in the form of a luxury tax, which was implemented in the 2003 season. Einolf argues that the adoption of the firm salary cap yields increases parity in the NFL, relative to MLB, since smaller market teams have a similar sized pool of funds for salaries in which to lure top talent.

Frick et al. (2003) examine four major sports in the United States. They assess the wage distributional effects in the NFL, NBA, MLB, and National Hockey League (NHL). They conclude that the link between salary inequality and team performance is indeed sport dependent. Increases in concentration are associated with higher winning percentages in the NBA, lower winning percentages in MLB, and maintain no statistical significance with winning in the NHL or NFL.

This study continues the research line starting with Lazear and Rosen (1981) by examining wage distribution as an effective tool for success in the NFL. It advances the existing research by employing new methods and by relaxing previous linearity assumptions. Allowing for the influence of salary distribution to be non-linear, it is possible that an optimal concentration can be found which offers the highest probability of team success.

An underlying assumption in this study is that pay reflects ability. In assessing the salary concentration of players, it is conjectured that the contribution towards team success of a player will match the amount paid to the player. Naturally, there are reasons for underperformance such as injury. It is assumed that these instances are random and in a large data set these instances are normally distributed and will not bias the results. This view is supported by research (Hendricks et al., 2003; Leeds & Kowalewski, 2001) which indicates that pay levels generally reflect skill level, though this view is not universally accepted in the literature.

**Methodology**

The relationship between the player and team is contractual. Once a player is selected, either by free agency or the draft, a contract is negotiated. The player’s services are provided to the team for the duration of the contract, unless traded to another team or voided in a manner stipulated by the contract. Once the contract
is completed, the player can negotiate with another team or seek a new contract with the existing team within the guidelines established by the CBA.

A player contract includes the base salary plus a variety of potential bonuses. Contract bonuses can be performance based, option years (either exercised by the player or the team), signing bonuses, or any number of additional types of bonuses. According to rules of the CBA, player salaries and bonuses are amortized over the length of the contract to obtain the player’s “salary cap value”. It is unlikely that the player’s salary cap value will match the funds actually received by a player from the team in any given year. The salary cap value is approximately the average yearly amount expected to be paid to the player over the life of the contract. Thus, the salary cap value is the perceived worth of the player, in terms of output to the team and contribution to team success. The player’s salary cap value is used in the analysis as the measure of player salary.

Using historical football data, a fixed effects model assesses the performance implications of various factors, including measures of team salary concentration. The study compiles the data of 32 NFL teams from 1999 through the 2009 seasons. The panel is unbalanced as the Houston Texans team did not begin play until the 2002 season (Pro-Football Reference, 2014: NFL, 2014; USA Today, 2014).

In the analysis, the performance measures are established as dependent variables to ascertain which elements are influential. The first performance measure is winning percentage (NFL, 2014). As the game changes and evolves over time, winning percentage is a useful because it provides a measure of team success compared to other teams playing under similar conditions.

The second measure of team performance is the margin of victory (Pro-Football Reference, 2014). Margin of victory is the average score differential of the team over the course of the season. A large positive margin of victory indicates a successful season. A negative margin of victory indicates a lack of success. The margin of victory provides a magnitude measure of team performance.

The final performance measure is the offensive yards rank of a team (Pro-Football Reference, 2014). Yearly rule changes and variation in player ability over time will influence a team’s offensive ability. Using ranking rather than total yards, the study can minimize the potential for yearly bias in the results. A ranking of one (1) indicates the most efficient offense in the league for gaining yards in the given year. A higher rank indicates less offensive ability.

Independent variables are tested to assess their impact on the performance measures (dependent variables). The first variable is the winning percentage lagged one season (NFL, 2014). While a portion of a team’s players will turnover each season, a significant number of players are under contract for multiple seasons. It is plausible that some of a season’s success will carrying forward into future seasons, and therefore reasonable to expect autoregressive tendencies with respect to winning. The winning percentage variable is lagged one period as
a control for residual influences from prior seasons.

The salary cap provides a range of funds which teams must spend on players. In addition to putting upper limits on what teams can spend, with few caveats, it also provides a lower limit teams must spend on salaries. If a team is building for future years, it is possible that they can cut salaries to the lower bound in a strategic attempt to better position themselves for future years, making success unlikely in the current year. A variable is calculated to represent the amount of team salary cap spending as a percentage of maximum salary cap available in a given year (USA Today, 2014).

The salary information is disaggregated in an attempt to assess the impact of salary concentration. For each year, the team’s Herfindahl-Hirschman Index (2014) is calculated.

\[
HHI = \left( \sum_{i=1}^{N} S_{i,t}^2 \right) \times 100
\]

where:
- \( i \) = player on the team
- \( N \) = total number of players on the team
- \( S_{i,t} \) = Salary cap share of player \( i \) in year \( t \)

This analysis also adds to existing research by relaxing an assumption of linearity. Non-linear assessment is completed with the inclusion of a second concentration term which is the squared HHI term.

It is possible that the size of market in which a team plays can influence performance, if players are attracted to a particular market. Players might be biased towards larger markets, as they might have more entertainment or peripheral activities available. Additionally, larger markets may provide more merchandising or promotional opportunities for a player. A link between market size and team performance has been noted previously (Zimmer, 2009). As the potential fan base of the team extends beyond a city limits, Metropolitan Statistical Area data from the U.S. Census (2012) are used in the study. The metro population estimates for 1999 to 2004 are from the 1990 U.S. Census, while the 2005 to 2009 metro population estimates are from the 2000 Census.

The salary data contains limitations and omissions. Every player on a football team is assigned a position. Unfortunately, much of the positional information is incomplete. The study can confidently use the positional salary data of quarterbacks and running backs. The top quarterback and running back from each team (as represented by the highest salary cap value) is captured each year. A quarterback
to running back ratio variable is created which provides information on the relative importance of these positions. The salary cap value of both quarterbacks and running backs are also included as a percentage of total available salary cap. Percentages provide a relative measure which is unbiased as the size of the total salary grows over time. As a larger percentage of the salary cap is devoted to these players, it may have an impact on team performance. Additionally, as these influences may be non-linear, the variables are also added as squared terms. Summary statistics for non-lagged and non-squared variables are presented in Table 1.

A fixed effects regression model is constructed for the unbalanced panel data set consisting of yearly team data from 1999 to 2009.

\[ Q = \beta_0 + \sum_{v=1}^{10} (\beta X_v) + \epsilon \]  

\( v = \) Independent Variables

Teams may have different attributes that can affect team performance which are unique to the team. This can be location, management, coaching, facilities, or a variety of factors specific to an individual team. The performance measures can also be influenced by yearly events such as changes in rules, training techniques, personnel, or other temporal conditions. To control for team specific and yearly influences, a fixed effects model is employed thus controlling for these influences as a matter of model selection. As the fixed effect model forces the same set of slope-coefficients on each team in every year, the analysis examines variable effects across all NFL teams and not a condition specific to a particular team or year.

Results

The performance measures are analyzed against independent variables. The results are provided in Table 1, 2, 3, and 4. The statistical significance of independent variables provide insights into the relationship between a team’s salary distribution characteristics and performance.
Table 1.
Summary Statistics Years 2000 to 2009

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winning %&lt;sup&gt;a&lt;/sup&gt;</td>
<td>49.97</td>
<td>19.34</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Average Margin of Victory</td>
<td>0.0003</td>
<td>6.41</td>
<td>-16.30</td>
<td>19.70</td>
</tr>
<tr>
<td>Offensive Yards Rank&lt;sup&gt;b&lt;/sup&gt;</td>
<td>16.43</td>
<td>9.18</td>
<td>1</td>
<td>32</td>
</tr>
<tr>
<td>HHI</td>
<td>4.21</td>
<td>0.77</td>
<td>2.65</td>
<td>8.43</td>
</tr>
<tr>
<td>Population</td>
<td>4,260,142</td>
<td>4,153,115</td>
<td>283,00</td>
<td>18,897,000</td>
</tr>
<tr>
<td>Quarterback/Running Back Ratio</td>
<td>2.45</td>
<td>2.94</td>
<td>0.10</td>
<td>25.76</td>
</tr>
<tr>
<td>Quarterback % of Cap</td>
<td>6.69</td>
<td>4.08</td>
<td>0.84</td>
<td>22.65</td>
</tr>
<tr>
<td>Running Back % of Cap</td>
<td>4.28</td>
<td>2.68</td>
<td>0.51</td>
<td>16.71</td>
</tr>
</tbody>
</table>

Note. There are 318 Observation.

The Houston Texans franchise started the 2002 Season

<sup>a</sup> Tie scores allowed in the Regular Season

<sup>b</sup> In years 2000-2001 there were 31 teams, lower rank is better

The lagged winning percentage variable is statistically insignificant as an influence on current winning percentage and margin of victory. However, it is statistically significant in the offensive yardage rank model. The lagged term is a control for residual influences. Other than prior seasons success suggesting some enhanced offensive ability, prior winning holds minimal influence on current success. This suggests difficulty in achieving long term success and parity of play in the NFL.
Table 2.
Fixed Effects Regression Results - Winning %

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coef.</th>
<th>Std. Error</th>
<th>t</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winning % Lagged 1 Period</td>
<td>-0.001</td>
<td>0.061</td>
<td>0.01</td>
<td>0.99</td>
</tr>
<tr>
<td>Team Cap Ratio to Maximum</td>
<td>42.59</td>
<td>13.03</td>
<td>3.27</td>
<td>0.00***</td>
</tr>
<tr>
<td>HHI</td>
<td>-26.48</td>
<td>10.35</td>
<td>2.56</td>
<td>0.01***</td>
</tr>
<tr>
<td>HHI squared</td>
<td>2.79</td>
<td>82,643.1</td>
<td>2.41</td>
<td>0.02**</td>
</tr>
<tr>
<td>Population</td>
<td>7.23E-06</td>
<td>4.17E-06</td>
<td>1.73</td>
<td>0.08*</td>
</tr>
<tr>
<td>Quarterback/Running Back Ratio</td>
<td>0.402</td>
<td>0.608</td>
<td>0.66</td>
<td>0.51</td>
</tr>
<tr>
<td>Quarterback % of Cap</td>
<td>1.276</td>
<td>1.117</td>
<td>1.14</td>
<td>0.25</td>
</tr>
<tr>
<td>Quarterback % of Cap squared</td>
<td>-0.114</td>
<td>0.073</td>
<td>1.56</td>
<td>0.12</td>
</tr>
<tr>
<td>Running Back % of Cap</td>
<td>-0.310</td>
<td>1.667</td>
<td>0.19</td>
<td>0.85</td>
</tr>
<tr>
<td>Running Back % of Cap squared</td>
<td>0.031</td>
<td>0.122</td>
<td>0.25</td>
<td>0.80</td>
</tr>
<tr>
<td>Intercept</td>
<td>41.48</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. Statistical Significance 1%***, 5%**, 10%*

Groups (Year: Team), $F(10,275) = 2.68$ or Prob > $F$ 0.0038
R-Sqr: within 0.0888, between 0.0000, overall 0.0019
Observations 317, Groups 32, Rho 0.7812

Team expenditures are shown to be statistically significant in determining the performance of a team. The ratio of the team’s salary cap expenditures to the maximum salary cap allowed is statistically significant and positive in the models for winning percentage and margin of victory. Teams that spend the maximum allowable salary cap have a greater probability of success. If a team spends less than allowed, either for financial reasons or strategically for future years, success is less likely in the current year.

The salary concentration of a NFL team is shown to be a statistically significant and a non-linear influence on team performance. The HHI variable is statistically significant in all three performance models. The coefficient of the HHI variable is negative in the winning percentage and margin of victory models, while positive in the offensive rank model. The concentration of salaries initially has a negative influence on winning percentage and margin of victory, while it increases (makes worse) the offensive rank of the team. The coefficient of the squared HHI term, however, is also statistically significant and positive in the winning percentage and
margin of victory models, while it decreases (makes better) the offensive rank of the team.

Table 3.
Fixed Effects Regression Results - Average Margin of Victory

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coef.</th>
<th>Std. Error</th>
<th>t</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winning % Lagged 1 Period</td>
<td>0.029</td>
<td>0.020</td>
<td>1.44</td>
<td>0.15</td>
</tr>
<tr>
<td>Team Cap Ratio to Maximum</td>
<td>12.84</td>
<td>4.21</td>
<td>3.05</td>
<td>0.00***</td>
</tr>
<tr>
<td>HHI</td>
<td>-8.04</td>
<td>3.35</td>
<td>2.40</td>
<td>0.02**</td>
</tr>
<tr>
<td>HHI squared</td>
<td>0.80</td>
<td>0.4</td>
<td>2.13</td>
<td>0.03**</td>
</tr>
<tr>
<td>Population</td>
<td>2.51E-06</td>
<td>1.35E-06</td>
<td>1.86</td>
<td>0.06**</td>
</tr>
<tr>
<td>Quarterback/Running Back Ratio</td>
<td>0.052</td>
<td>0.197</td>
<td>0.26</td>
<td>0.79</td>
</tr>
<tr>
<td>Quarterback % of Cap</td>
<td>0.244</td>
<td>0.361</td>
<td>0.68</td>
<td>0.50</td>
</tr>
<tr>
<td>Quarterback % of Cap squared</td>
<td>-0.022</td>
<td>0.024</td>
<td>0.93</td>
<td>0.35</td>
</tr>
<tr>
<td>Running Back % of Cap</td>
<td>-0.064</td>
<td>0.539</td>
<td>0.12</td>
<td>0.91</td>
</tr>
<tr>
<td>Running Back % of Cap squared</td>
<td>0.010</td>
<td>0.039</td>
<td>0.25</td>
<td>0.80</td>
</tr>
<tr>
<td>Intercept</td>
<td>-4.18</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. Statistical Significance 1%***, 5%**, 10%*

Groups (Year: Team), F(10,275) = 3.14 or Prob > F 0.0008
R-Sqr: within 0.1026, between 0.0000, overall 0.0019
Observations 317, Groups 32, Rho 0.8037

Increasing team salary concentration initially is a negative influence on term performance. However, beyond a threshold, further salary concentration increases team performance. The best potential for NFL team success resides at either extreme of high or low player salary concentration (Figure 1). The minimum point of team performance (worst probability for team success) holding all other elements constant is achieved at an HHI of approximately 4.7. The league average during the study is approximately 4.2.
**Table 4.**

*Fixed Effects Regression Results - Offensive Yards Rank*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coef.</th>
<th>Std. Error</th>
<th>t</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winning % Lagged 1 Period</td>
<td>-0.076</td>
<td>0.026</td>
<td>2.89</td>
<td>0.00***</td>
</tr>
<tr>
<td>Team Cap Ratio to Maximum</td>
<td>1.73</td>
<td>5.57</td>
<td>0.31</td>
<td>0.76</td>
</tr>
<tr>
<td>HHI</td>
<td>17.02</td>
<td>4.42</td>
<td>3.85</td>
<td>0.00***</td>
</tr>
<tr>
<td>HHI squared</td>
<td>-1.71</td>
<td>0.5</td>
<td>3.47</td>
<td>0.00***</td>
</tr>
<tr>
<td>Population</td>
<td>-4.41E-06</td>
<td>1.78E-06</td>
<td>2.47</td>
<td>0.01***</td>
</tr>
<tr>
<td>Quarterback/Running Back Ratio</td>
<td>0.094</td>
<td>0.260</td>
<td>0.36</td>
<td>0.72</td>
</tr>
<tr>
<td>Quarterback % of Cap</td>
<td>-1.707</td>
<td>0.477</td>
<td>3.58</td>
<td>0.00***</td>
</tr>
<tr>
<td>Quarterback % of Cap squared</td>
<td>0.093</td>
<td>0.031</td>
<td>3.00</td>
<td>0.00***</td>
</tr>
<tr>
<td>Running Back % of Cap</td>
<td>-0.197</td>
<td>0.713</td>
<td>0.28</td>
<td>0.78</td>
</tr>
<tr>
<td>Running Back % of Cap squared</td>
<td>0.014</td>
<td>0.052</td>
<td>0.26</td>
<td>0.80</td>
</tr>
<tr>
<td>Intercept</td>
<td>3.17</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note.**  
*Statistical Significance 1%***, 5%**, 10%*

Groups (Year: Team), F(10,275) = 5.47 or Prob > F 0.0000  
R-Sqr: within 0.1659, between 0.0144, overall 0.0002  
Observations 317, Groups 32, Rho 0.8815

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**Figure 1**

*Influence of Salary Concentration (HHI) on Winning Percentage  
(Higher is Better)*
Teams make player salary decisions facing a multitude of competing objectives and goals. Financially, a team can benefit from a high level of team performance through increased interest in the team and higher attendance. A team can also benefit from merchandising and national exposure generated from elite talent. At the low extreme of salary concentration, lacking elite talent can diminish the prospects of national visibility. This can lower fan interest and adversely impact television ratings, attendance, promotions, and merchandising. Of the salary extremes, the acquisition of elite talent and salary concentration leads to the potential for both team performance success and the ability to generate greater revenues.

The population variable is a statistically significant influence on team performance. It is a positive influence on winning percentage and margin of victory, and decreases (makes better) the offensive yards ranking. In all three performance measures, the population variable indicates a positive bias. It is possible that larger markets are more easily able to attract better talent, which leads to better on field performance.

The quarterback / running back ratio variable is insignificant. The ratio of expenditures towards these positions does not appear to influence team performance. The running back variables are also insignificant in all models. Increasing the percentage of the salary cap allocated towards a better running back did not impact team performance.

The quarterback variable is insignificant in winning percentage and margin of victory models, but is a statistically significant non-linear influence on the offensive yardage rank. The offensive yardage ranking decreases (gets better) with a higher portion of the salary cap devoted to the quarterback position (Figure 2). However, spending beyond approximate 9% of the salary cap on the quarterback, the offensive ranking begins to increase (gets worse). Some quarterbacks may play at levels which warrant salaries in excess of 9% of the available salary cap. However, when paying the starting quarterback more than 9% of the salary cap there are fewer remaining financial resources to pay for players to catch, run, and block. The net result of surpassing the 9% threshold is a decreased probability of offensive efficiency. The 9% threshold of quarterback play is approximately one standard deviation higher than the NFL league average. The optimal quarterback, from an offensive efficiency standpoint, is one which is about one standard deviation better than league average.
Discussion

The study provides results which are consistent with prior research starting with Lazear and Rosen (1981) and more specifically with Rosen (1981). NFL teams are able to achieve success by acquiring “star” players.

Additional research can be done to further the study, particularly in the area of positional influence. Access to a complete data set would open several lines of inquiry in assessing spending levels by position and the impact of ratio spending on offense to defense. The date of the study precedes the implementation of restrictions on rookie salaries. Further research can determine whether the rookie pay scale alters the results. Finally, the data are sourced from public databases which limit the access to available explanatory variables. The study would be assisted with additional explanatory variables to help tease out causal influences.

Conclusion

The results confirm performance parity in the NFL and that prior victories do not translate into current success. With little residual effect evident, teams struggle to maintain or increase their winning percentage in each season. Teams must spend their full allotment of funds on player salaries to obtain victory. Spending under the salary cap allowance diminishes the chances of success. It is indicated that acquiring elite talent, especially at the quarterback position, can help secure team wins. The
optimal amount to spend on the starting quarterback is shown to be approximately 9 percent of a team’s salary cap. No indication is provided for benefits of acquiring an elite running back. The results also show a large market bias in the performance measures suggesting an ability of larger markets to effectively lure talent.

The influence of salary concentration in the NFL is shown to be non-linear. Either extreme of low or high salary concentration provides the best probability of team success. A team’s performance declines as they add talent until a threshold of 4.7 HHI is achieved, after which further increases in talent translates into better team performance. Given potential financial considerations, it is likely that a team’s best option for high levels of performance is the acquisition of elite talent and increased salary concentration. While every sport is different, results of the study suggest that in the NFL, it is better to have fewer elite players than many good players.

References


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