Team Payroll Versus Performance in Professional Sports: Is Increased Spending Associated with Greater Success?

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2017

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Acknowledgements

I would like to thank my thesis advisor, Peter Arcidiacono, for his valuable guidance. I would also like to acknowledge my honors seminar instructor, Kent Kimbrough, for his continued support and feedback. Lastly, I would like to recognize my honors seminar classmates for their helpful comments throughout the year.

Abstract

Professional sports are a billion-dollar industry, with player salaries accounting for the largest expenditure. Comparing results between the four major North American leagues (MLB, NBA, NHL, and NFL) and examining data from 1995 through 2015, this paper seeks to answer the following question: do teams that have higher payrolls achieve greater success, as measured by their regular season, postseason, and financial performance? Multiple data visualizations highlight unique relationships across the three dimensions and between each sport, while subsequent empirical analysis supports these findings. After standardizing payroll values and using a fixed effects model to control for team-specific factors, this paper finds that higher payroll spending is associated with an increase in regular season winning percentage in all sports (but is less meaningful in the NFL), a substantial rise in the likelihood of winning the championship in the NBA and NHL, and a lower operating income in all sports.

JEL Classification: Z2; Z20; Z23; J3.

Keywords: Sports; Payroll; Performance; Competitive Balance.

TABLE OF CONTENTS PAGE

1 Introduction

During their respective 2015 seasons[1], the four major North American professional sports leagues – comprised of the Major League Baseball (MLB), National Basketball Association (NBA), National Hockey League (NHL), and National Football League (NFL) – cumulatively earned $30.52 billion in revenue and spent $25.53 billion in total expenditures. Player expenses accounted for the largest component at $14.97 billion, responsible for nearly 60% of total expenditures. Table 1 provides a one-year snapshot into each league's financial data, but this proportion has remained relatively constant over the past 20 years, primarily due to arrangements in each sport's collective bargaining agreement between each league and their respective players' association. The significant portion spent on player personnel illustrates their perceived key role in driving organizational performance (both on and off the field). However, the exact relationship between team payroll and performance is unclear, leading one to consider if paying players more money is linked to greater achievement. One would believe that a player's salary should be based on their athletic prowess, with compensation commensurate with capability, but the full impact of this relationship remains unclear. Specifically, the examination between a team's payroll and their resulting performance merits further quantitative and qualitative analysis in order to understand if increased spending on players is associated with greater success, as measured in a multitude of ways.

Table 1 – *League Financials for 2015 Season ($ Billions)*

	Total Revenue	Total Expenses	Player Expenses	Players Expenses as % of Total	Operating Income
MLB	$8.39	$7.72	$4.42	57.25%	$0.68
NBA	$5.87	$4.92	$2.73	55.47%	$0.95
NHL	$4.10	$3.66	$2.07	56.52%	$0.44
NFL	$12.16	$9.23	$5.75	62.29%	$2.92
Total	$30.52	$25.53	$14.97	58.64%	$4.99

Note. Financial figures obtained from *Forbes'* annual estimates.

The four major sports leagues all employ different policies regarding player compensation, but the key difference deals with the restrictiveness of their salary caps, which create limits on how much teams can spend on player salaries. Understanding these differences is

[1] "2015 season" refers to the season that began in 2015 (some of the leagues have seasons that start in one year and finish in the next). See Appendix Table A1 for additional key differences across sports.

a fundamental element of this research on player compensation and team performance. When ranking each league based on the amount of freedom teams have to decide how much they want to spend, the MLB allows the greatest flexibility and is closely followed by the NBA, while the NHL and NFL have the strictest limits (Staudohar, 1998). Throughout the entirety of the paper, I will refer to each sport in the same sequence (MLB, NBA, NHL, and NFL), which has been ordered from least to most restrictive. The MLB has no salary cap and instead implements a luxury tax, whereby teams whose total payroll exceeds a certain figure (determined annually) are taxed on the excess amount in order to discourage teams from having a substantially higher payroll than the rest of the league. Since 2003, only seven different franchises have had to pay luxury taxes, with typically two to three teams paying fees each year (ESPN, 2015). The NBA uses a combination of a soft cap and a luxury tax, permitting several significant exemptions that allow teams to exceed the pre-defined limit, but also requiring a luxury tax payment if the team payroll exceeds the cap by a certain amount. Unlike the MLB, this limit is frequently surpassed, as 26 franchises have had to pay luxury taxes since 2003, with roughly five to six offenders each year (Shamsports, 2015). Lastly, the NHL and NFL employ hard caps, firmly restricting the total amount a team can spend, allowing essentially zero flexibility[2] (in fact, teams have been severely punished when they were found to have paid players in excess of the cap). While it is evident that the four major U.S. sports leagues utilize a continuum of salary caps, its impact on the relationship between salary spent and team success has remained unclear.

This research aims to empirically analyze the relationship between a team's payroll and the success they achieve, comparing the findings across the four major North American professional sports leagues. While there are many ways to gauge success, this research examines the relationship between a team's payroll and performance across three dimensions: regular season success, postseason success, and financial success. These metrics diverge between leagues, as their respective regular seasons have different characteristics, playoffs have unique structures, and team finances greatly differ across leagues, which all complicate a perfect apples to apples comparison. However, the overarching idea of examining the statistical significance of any potential correlations remains consistent throughout. More generally, although these metrics

[2] The NFL salary cap allows teams to "carryover" unused cap space from the previous year. For illustrative purposes, assume that the salary cap in the NFL for the 2014 and 2015 seasons was $140 million. If the San Francisco 49ers spent $130 million in 2014, $10 million would rollover into the next season, allowing them to spend up to $150 million in 2015.

are not independent from one another, they represent three of the most crucial benchmarks of success through their measurement of regular season achievement, postseason accomplishment, and financial performance, and are relevant to each of the leagues.

This research begins by highlighting the key findings of prior relevant literature. Next, it explains the theoretical framework behind some central concepts including the labor market in professional sports, competitive balance, salary caps, and free agency. Subsequently, the paper quantitatively analyzes payroll data between from 1995 through 2015 (selected based on data availability and the desire to examine as far back as possible) across the four leagues, revealing how team spending is related to various metrics of success. Idiosyncratic differences across the leagues are investigated further to provide rationale that may explain the results. This component is tightly connected to the quantitative analysis and various additional statistical comparisons, but also strives to incorporate qualitative explanations that are based on the fundamental nature of each sport. Ultimately, the paper aims to determine the relationship between payroll and success and examine the underlying factors driving results both within and across leagues.

2 Literature Review

Many have previously researched the intersection between sports and finance. Within the area, a variety of subtopics have been explored. Most relevant to this paper, some have previously sought to examine if team payroll is linked with team performance. However, while there does exist significant work on this relationship, most of the prior literature has predominantly focused on baseball. While this correlation has been explored in isolation, a comparison across the four major leagues remains uncharted. Therefore, great gains can be made in undertaking this research and comparing the results from the quantitative and qualitative analysis.

In a paper that most closely mirrors the intended analysis of this research, Hasan (2008) examined data from the MLB from 1992 to 2007 and investigated the relationship between team performance and payroll, comparing the winning percentages and payrolls of MLB teams. Hasan looked at a team's performance over the course of the 162-game regular season, believing that the larger sample size of games would provide a more accurate picture of a team's success (versus extending into the playoffs). Additionally, Hasan decided against using a team's regular season ranking as an indicator of success, illustrating the inherent problem associated with such an approach by explaining that difference between a team ranked 5th and a team ranked 15th is not necessarily by a factor of three (i.e. the 5th ranked team did not win three times as many games as the 15th). Ultimately, Hasan ran the following OLS regression model:

$$WinPercent_t = \alpha + \beta * Payscale_t + \varepsilon_t \quad (1)$$

where $Payscale_t$ is a team's actual payroll divided by the average payroll for the overall league in year t. He found there was a statistically significant positive association between payroll and regular season winning percentage. Specifically, Hasan stated that "sufficient evidence was found that regular season outcomes are highly influenced by how much the teams spend on their players" (p. 4). Some of Hasan's methodology forms the baseline of this paper, but this research attempts to greatly expand upon his approach. While his rationale behind solely examining the regular season is correct (larger sample size of games may be more indicative of a team's ability), testing whether regular season performance extends into the postseason provides many additional rich insights. Teams are frequently judged by how they fare in the playoffs, so solely examining the regular season ignores a critical component of success. Additionally, Hasan's scope narrowed in on MLB, whereas this paper explores that relationship across multiple leagues. Nevertheless, this paper expands on Hasan's work by leveraging (and extending) certain statistical methodologies as well as validating the relationship between performance and payroll across the major sports leagues.

In 2000, the MLB commissioned a study to examine if revenue disparities among clubs were damaging competitive balance and sought recommendations on structural reforms to address the problem. For analytical purposes, Levin, Mitchell, Volcker, and Will (2000) divided the clubs into quartiles by ranking them (based on payroll) from high to low and separating the clubs into four roughly equal buckets (i.e. Quartile I consisted of the top 25% highest spending teams and Quartile IV included the bottom 25% lowest spending teams). Among the many findings, Levin et al. found that a large and growing revenue disparity existed, which created problems of chronic competitive imbalance, a trend that substantially worsened following the strike shortened 1994 season. Additionally, Levin et al. wrote that "although a high payroll is not always sufficient to produce a club capable of reaching postseason play—there are instances of competitive failures by high payroll clubs—a high payroll has become an increasingly necessary ingredient of on-field success" (p. 4). From this perspective, Levin et al. explain that a high payroll does not necessarily ensure high performance, but rather is a prerequisite to achieve success, severely impacting the league's competitive balance. Furthermore, Levin et al. delineated a methodology for determining payroll parity. They explained that they believe an indicator of parity would be a ratio of approximately 2:1 between the average payroll of Quartile I clubs to that of Quartile IV clubs. However, during the three years preceding the release of their study, they found that the ratio of the average payroll of Quartile I teams divided by Quartile IV was 1.5:1 in the NFL, 1.75:1 in the NBA, and over 2.5:1 in the MLB, reaffirming their stance that the MLB lagged behind the other two in terms of payroll competitive balance. Overall, Levin et al.'s study clearly elucidates that a team's payroll is associated with their postseason success in the MLB, and offers an operational approach to quantifying and comparing payroll parity across leagues[3].

While less prevalent, some studies have researched the relationship between player salaries and team financial performance. In a 2015 paper, "Performance or Profit: A Dilemma for Major League Baseball," Steven Dennis and Susan Nelson examined the effect of team payrolls on the revenues, profits, and winning percentages of MLB teams from 2002 to 2010. They ran regressions on a variety of financial metrics, but the two most relevant include:

$$TeamRevenue_{i,t} = \alpha + \beta * TeamSalary_{i,t} + \varepsilon_t \quad (2)$$

$$TeamOperatingIncome_{i,t} = \alpha + \beta * TeamSalary_{i,t} + \varepsilon_t \quad (3)$$

which both yielded some interesting conclusions. Namely, Dennis and Nelson write that "the motivation of a MLB team owner may not be simply to maximize profits; maximizing winning percentages also comes into play. Although team revenues are higher when player salaries are higher, the increase in revenue is less than one-for-one with an increase in player salaries. As a result, gross profit margin decreases with player salary increases" (p. 6). From this perspective, we see that organizations may be faced with a competing choice of whether to maximize profits or winning. When franchises spent more money, Dennis and Nelson found that teams tended to have higher winning percentages. However, although revenues also generally increased as teams had higher payrolls, the associated expenses outpaced this rise in revenue, causing gross profit margin (computed as revenue less payroll, divided by revenue) to fall. In subsequent analysis, this paper computes analogous regressions and examines a similar contrast between winning and

[3] Updated calculations for all four leagues have been reported in Figure 8 and are discussed in Section IV of this paper.

profits, comparing results across leagues and providing explanations based on infrastructural differences.

In yet another study on the MLB, Hall, Szymanski, and Zimbalist (2002) utilized team payroll data between 1980 and 2000 to examine the connection, implementing Granger causality tests to establish whether the relationship runs from payroll to performance or vice versa. Hall et al. write that although "there is no evidence that causality runs from payroll to performance over the entire sample period, the data shows that the cross-section correlation between payroll and performance increased significantly in the 1990s" (p. 149). This finding illustrates an important idea that is considered throughout the entirety of this paper. The relationship between payroll and performance is not static, meaning that the results may vary over time. Although this may appear at first glance to be an unsettling conclusion, it reaffirms the importance of understanding important events and trends that have occurred in the four leagues over the course of the past 20 years. The key takeaway is that while statistical methods may uncover certain patterns, a deep historical knowledge of the idiosyncratic elements of each sport are essential to uncovering the underlying influence.

Differences in correlations between payroll and success across the leagues may potentially be derived from the underlying nature of each sport. In an article comparing the labor markets in the MLB and NFL, Dubner (2007) attempts to explain the diverging power dynamics in each league. At a high level, a commonly held belief is that players have more influence in MLB, while a team's ownership has more power in the NFL (often at the expense of individual players). This manifests itself in higher paying contracts with more guaranteed money for baseball players. Diving deeper into the economics of each sport, the MLB and NFL operate under dissimilar business models. MLB teams are run at a much more local level, with less than 25% of all league revenues distributed evenly among all 30 organizations. The remaining 75% of revenues are earned and kept at a local level, with a disproportionate share going to franchises in large markets with strong team brands and greater on-field success. This increases the volatility for the primary revenues of a baseball team (ticket sales, luxury suite rentals, local broadcast ratings, and subsequent rights fees) which can all rise and fall with winning and losing seasons. Conversely, 80% of the NFL's revenue is divided evenly among the 32 teams, and empirical evidence clearly shows that market size has little impact on the revenue base of an NFL club. Although revenue sharing and market factors are tangential to the core focus of this paper, they provide profound intuitions into the structural differences of the labor markets of the two sports, possibly explaining potential dissimilarities that may emerge.

Given the magnitude of team payrolls, many have attempted to analyze whether higher player payrolls are associated with increased team success. While many previous studies have thoroughly explored this area, so far much of the research has concentrated on individual salaries and the player's corresponding performance. Of the research that has been completed at the team level, most has focused primarily on baseball. However, limited research has been made in comparing the relationship between the four major professional sports leagues. While the existing research has predominantly used a couple methodologies (pay-scales and pay-quartiles), this paper intends to build upon each of them to best match the metric of success being examined (regular season, postseason, and financial success).

This paper contributes to the existing research in a variety of ways, delivering rich insights into the differences across the various leagues and juxtaposing the relationships across several benchmarks of success. At its core, this paper supplements the current research in five ways. First, all four professional sports leagues have been included in the analysis (rather than only one), allowing for relative comparisons across leagues. Second, the relationship has been examined across multiple metrics of success, instead of solely looking at regular season winning percentage. Third, the empirical methodology is more robust, controlling for team-specific factors. Fourth, this work provides an updated time frame of analysis, examining seasons from 1995 through 2015. Lastly, this paper attempts to highlight league and team-specific factors in order to logically explain divergent findings.

3 Theoretical Framework and Empirical Regulators

The massive amount of money involved in professional sports underscores how organizations are increasingly run like traditional businesses, influencing how team executives make decisions on a day-to-day basis. Since every organization has a unique utility function, each places a different priority on team success and financial profit. Accordingly, executives make personnel decisions under a diverse set of preferences, creating a labor market where teams must decide how to best leverage their various assets to achieve their desired goals. There are a handful of critical concepts that will provide essential context for understanding various dynamic factors that underpin the relationship between payroll and performance. The following subsections will outline these concepts and relate them to the core research objectives.

3.1. Labor Market in Professional Sports

The primary method used by franchises to improve team performance is to acquire and retain top talent (via trade, free agency, draft, or re-signing), frequently competing with other organizations to employ the best players. This competitive dynamic means teams strive to provide the most attractive offer, which can include an array of factors beyond money, such as elite coaching, high-class medical services, and premier training facilities. To understand the basic economics of the labor market, it is helpful to briefly evaluate the situation from the demand (team) and supply (player) perspective.

On the demand side, franchises value players based on the benefits that they will provide. While this most importantly centers upon their ability to perform on the field, it also includes a myriad of ancillary factors such as a player's leadership ability, personality fit with existing teammates, and marketing potential. Based on a team's complete evaluation of a player, they can decide if they would like to attempt to employ that individual by offering compensation that is representative of how much they value that athlete. If the labor market was perfectly efficient, each player would go to the team that values them the most, with all teams offering contracts that matched how much they valued that specific individual. However, that is not necessarily the case in practice. An assortment of factors distort the market, including salary caps which introduce a constraint on the amount a team can pay players, minimum salaries that establish a price floor, and maximum salaries that set a price ceiling. At the end of the day, personnel decisions are made by humans who may be motivated by different goals, whether that be winning, generating profits, or simply retaining their job. While these all can inject potential distortions between what an athlete is theoretically worth and what they actually earn, players generally receive compensation that is proportionate with their abilities. Therefore, one would expect that teams that spend the most amount of money will be able to accrue the greatest amount of talent, presumably leading to the greatest success.

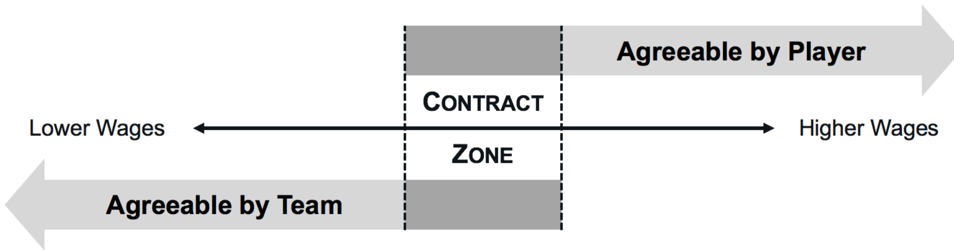

Figure 1. Competing preferences in professional labor market.

Since contracts must be mutually agreeable, it is important to view things from players' perspectives as well. The contrasting preferences of teams and players are illustrated in Figure 1, whereby the "contract zone" represents the negotiation range in which both sides might agree on the terms of a contract (Leeds and Allmen, 2011). The primary (and most quantifiable) factor at an organization's disposal is the financial compensation they are willing to offer in exchange for a player's services, and at the end of the day, like any other job, professional athletes tend to accept offers where they receive the highest compensation. Therefore, this paper is predominantly framed from the perspective of teams since they have the power to determine the strategic priorities of their organization.

3.2. Competitive Balance

One of the oldest adages in sports is that on any given day, each team has a chance to beat the other. If only a few teams regularly won and the rest almost always lost, games would be decidedly less interesting. Since professional sports fundamentally serve as a form of entertainment, successful leagues must be based on relatively even competition. The concept of competitive balance is central to my topic, since one of the primary mechanisms leagues use to increase parity is the creation of payroll restrictions (like salary caps and luxury taxes).

While there are many opinions on the matter, there are two prevalent approaches to measuring competitive balance (Leeds and Allmen, 2011). The first method focuses on team performance over the course of a single season. By examining the dispersion of winning percentages, one can see the disparity between high and low performing teams. The second approach looks across multiple seasons, measuring the concentration of championships over a given period. Both approaches have merit, so it is important to consider both types of variation in order to get a more complete picture.

3.2.i. Within-Season Variation

The first approach to quantifying competitive balance looks at the dispersion of teams in a given season. The subsequent procedures for computing competitive balance closely follow those delineated by Brad Humphreys in his widely-cited paper, "Alternative Measures of Competitive Balance in Sports Leagues" (2002). Generally, measures of within-season variation are based on the standard deviation of winning percentages. In professional sports, there is a winner and loser in each game, so the average winning percentage is 0.500, where the standard deviation is defined:

$$\sigma_{w,t} = \sqrt{\frac{\sum_{i=1}^{N}(WPCT_{i,t} - 0.500)^2}{N}} \tag{4}$$

where $WPCT_{i,t}$ is the winning percentage of the *i*th team in year *t* and *N* is the number of teams in the league. While the standard deviation of winning percentages provides a helpful summary of competitive balance, it has significant limitations, namely that the standard deviation varies with the number of games in a season. The shorter a league's season, the greater the likelihood that random variation alone will produce winning percentages that substantially differ from 0.500[4]. Thus, to account for the differences in number of games, additional modifications are required. First, we can compute the theoretical standard deviation of winning percentage if every team was exactly equal (i.e. each team has exactly a 50% chance of winning each game). Since this indicates perfect parity, we can call this the "ideal" standard deviation. The formula for the standard deviation of this theoretical scenario is expressed:

$$\sigma_I = \frac{0.50}{\sqrt{G}} \tag{5}$$

where 0.50 indicates each team has a 50% chance of winning and G is the number of games in a season. These calculations reveal an "ideal" standard deviation of 0.039 in the MLB, 0.055 in the NBA and NHL, and 0.125 in the NFL. Using these two measures of average variation, we can define the Competitive Balance Ratio (*CBR*) as follows:

$$CBR = \frac{\sigma_w}{\sigma_I} \tag{6}$$

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[4] To illustrate, imagine flipping a fair coin four times. Applying the binomial distribution, we know that the probability of observing an extreme outcome of all heads or all tails is 12.5% (1 out of 8 times). If a coin is flipped 10 times, the odds of getting all heads or all tails plummets to 0.2% (1 out of 512 times). As we continue to increase the number of coin flips, the chances of an extreme outcome become increasingly remote.

Table 2 reveals that the NBA has the highest ratio between actual standard deviation and the theoretical value at 2.83, indicating that basketball has the least parity in-season. On the other end of the spectrum, the NFL has the lowest *CBR* at 1.52, suggesting the greatest parity amongst all leagues. The MLB and NHL sit between the other two sports, with ratios of 1.77 and 1.62, respectively. From this initial examination, we can begin to see that there exists fundamental differences across the four leagues. When comparing competitive balance from a within-season perspective, we see that the NBA had the least parity while the NFL had the greatest equity, with the MLB and NHL finishing in between the other two. Loosely, this follows what one would expect given each leagues' salary cap restrictiveness, as the two sports with strongest caps (hockey and football) showed the greatest competitive balance.

Table 2 – *Dispersion of Winning Percentages (1995 – 2015)*

	MLB	**NBA**	**NHL**	**NFL**
Mean SD	0.070	0.156	0.090	0.190
Ideal SD	0.039	0.055	0.055	0.125
CBR	1.77	2.83	1.62	1.52

3.2.ii. Between-Season Variation

The second approach to measuring competitive balance attempts to look at how teams finish differently on a year-to-year basis. Graphically, one way to examine this is by comparing how well a team does from one year to the next[5]. In Figure 2, I have overlaid standard boxplots on top of violin plots[6] to show how much a team's winning percent tends to change from one season to the next. Ranking them from most to least persistent, we see that teams in the MLB and NHL generally had fairly similar winning percentages each year. Teams in the NBA tended to have a little more turnover, while the NFL clearly showed the greatest year-over-year changes in how well a team performed. However, it is important to note that this does not control for differences in the number of games in a season, which we previously mathematically showed that extreme outcomes are more likely when there are fewer games. Nevertheless, Figure 2 provides an informative baseline for subsequent analysis.

[5] The values are calculated by subtracting the previous years' win percentage from the current one. For instance, if a team won 40% of games this year and 60% last year, that would correspond to a change of -20%.

[6] Boxplots demarcate basic distribution values including the median, 25th percentile, and 75th percentile. Violin plots are mirrored histograms, with the width of the plot corresponding to the frequency of that event. That means that wider areas correspond to more common outcomes.

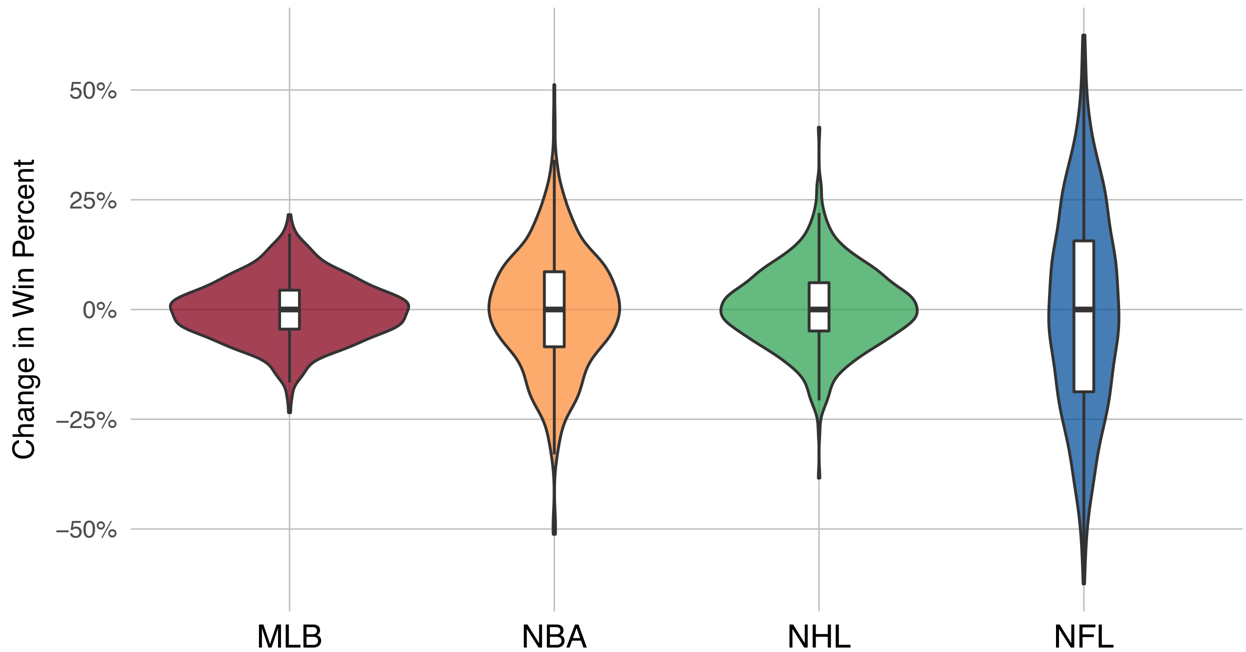

Figure 2. Change in team win percent between consecutive years from 1995 to 2015.

Computationally, there are multiple ways of investigating how much league results change year-over-year. One common approach is to apply the Herfindahl-Hirschman Index (*HHI*), which was developed to measure the concentration of firms in an industry but can be used to measure the concentration of league championships. It is defined:

$$HHI = \sum_i \left(\frac{c_i}{T}\right)^2 \quad (7)$$

where c_i is the number of championships team i won in a given period and T is the number of years in the period. The minimum of *HHI* is 1/N, which corresponds to a scenario in which all teams alternate championships, while the maximum is 1, which would indicate complete imbalance (with one team winning every time). In Table 3, I have calculated the results from 1995 through 2015. When considering the concentration of championships, the NBA has the largest *HHI* value at 0.17, indicating that it had the highest concentration of winning. This makes intuitive sense, since four teams (the Los Angeles Lakers, San Antonio Spurs, Chicago Bulls, and Miami Heat) accounted for 16 of the 21 titles won during that span. The NFL had the smallest *HHI* value of 0.11, further reinforcing its status as the league with the greatest parity. This figure is somewhat buoyed by the New England Patriots' four titles and the Denver Broncos' three championships, but is consistent with history as 12 different franchises have won during the past 21 seasons. Again, the MLB and NHL reside in between the NBA and NFL, as each league only has a few franchises that have won three or more titles, with the majority of the other championships awarded to single-title teams. When comparing competitive balance from a between-season perspective, we see a familiar pattern, with the NBA having the least parity and the NFL showing the greatest balance, with the MLB and NHL in between.

Table 3 – *Distribution of Championships (1995 – 2015)*

	MLB	**NBA**	**NHL**	**NFL**
Titles by Franchise	Yankees—5 Giants—3 Red Sox—3 Cardinals—2 Marlins—2 Angels—1 Braves—1 Diamondbacks—1 Phillies—1 Royals—1 White Sox—1	Lakers—5 Spurs—5 Bulls—3 Heat—3 Cavaliers—1 Celtics—1 Mavericks—1 Pistons—1 Warriors—1	Red Wings—4 Blackhawks—3 Avalanche—2 Devils—2 Kings—2 Penguins—2 Bruins—1 Ducks—1 Hurricanes—1 Lightning—1 Stars—1	Patriots—4 Broncos—3 Giants—2 Packers—2 Ravens—2 Steelers—2 Buccaneers—1 Colts—1 Cowboys—1 Rams—1 Saints—1 Seahawks—1
HHI	0.13	0.17	0.12	0.11

3.2.iii. Lorenz Curve

Lorenz curves can be used to graphically express competitive balance. Commonly used in economics, Lorenz curves illustrate how evenly a resource is distributed throughout a population. Applied to sports, we can use the same logic to see how equitable wins are in each league. To understand how it is interpreted, consider the NBA's 2015 regular season. Since all 30 teams play an 82-game schedule, there are 1,230 total games (and hence 1,230 possible wins) over the course of the season. The three worst teams (the Philadelphia 76ers, Los Angeles Lakers, and Brooklyn Nets) combined to win only 48 games. Thus, the bottom 10 percent of NBA teams combined to account for only 3.9% of the NBA's wins. Conversely, the three best teams (the Golden State Warriors, San Antonio Spurs, and Cleveland Cavaliers) collectively won 197 games, meaning that the top 10 percent of teams accounted for 16.0% of the NBA's wins. Undertaking a similar analysis for the MLB's 2015 season reveals a more equitable picture. During a 162-game season, the thirty teams play a total of 2,430 games[7]. The three weakest

[7] A game between the Detroit Tigers and the Cleveland Indians was canceled, so there were only 2,429 games during the 2015 season.

teams (the Philadelphia Phillies, Cincinnati Reds, and Atlanta Braves) combined to win 194 games, accounting for 8.0% of the MLB's wins. Meanwhile, the three strongest teams (the Saint Louis Cardinals, Pittsburgh Pirates, and Chicago Cubs) accumulated 295 wins, accounting for 12.1% of the MLB's wins. Hence, we see that the 2015 MLB season experienced a more equitable distribution of wins amongst its teams.

In a perfectly equal world, every team would win an equal amount, meaning that any 10 percent of the population will account for 10 percent of the wins. While this would not make for a very entertaining league, this "ideal" Lorenz curve represented by the diagonal dashed line in Figure 3. As imbalance increases, the actual Lorenz curve sags further below the ideal. Figure 3 depicts that the MLB and NHL closely resemble one another and show the greatest parity, while the NBA and NFL show greater inequity. This conclusion slightly diverges from previous findings that showed the NFL had the greatest parity. However, this is consistent in justifying the calculations used to find each league's *CBR*, where we found that increasing the number of games decreases the dispersion of winning percentages. More interestingly, Figure 3 seems to show a curious dichotomy between sports, as the Lorenz curves for the MLB and NHL closely resemble one another, as do the curves for the NBA and NFL. One noteworthy characteristic is that runs in baseball and goals in hockey tend to be harder to come by, with most games generally finishing in single digits. Conversely, games in the NBA and NFL tend to have much higher scores. Thus, in sports where games are decided by fewer units, luck appears to play a more significant role, as a few particular plays can have a profound impact on the final score (and the outcome of the game). This underscores an important note that the fundamental nature of each sport differs, and that perfect comparisons across leagues are likely unreasonable.

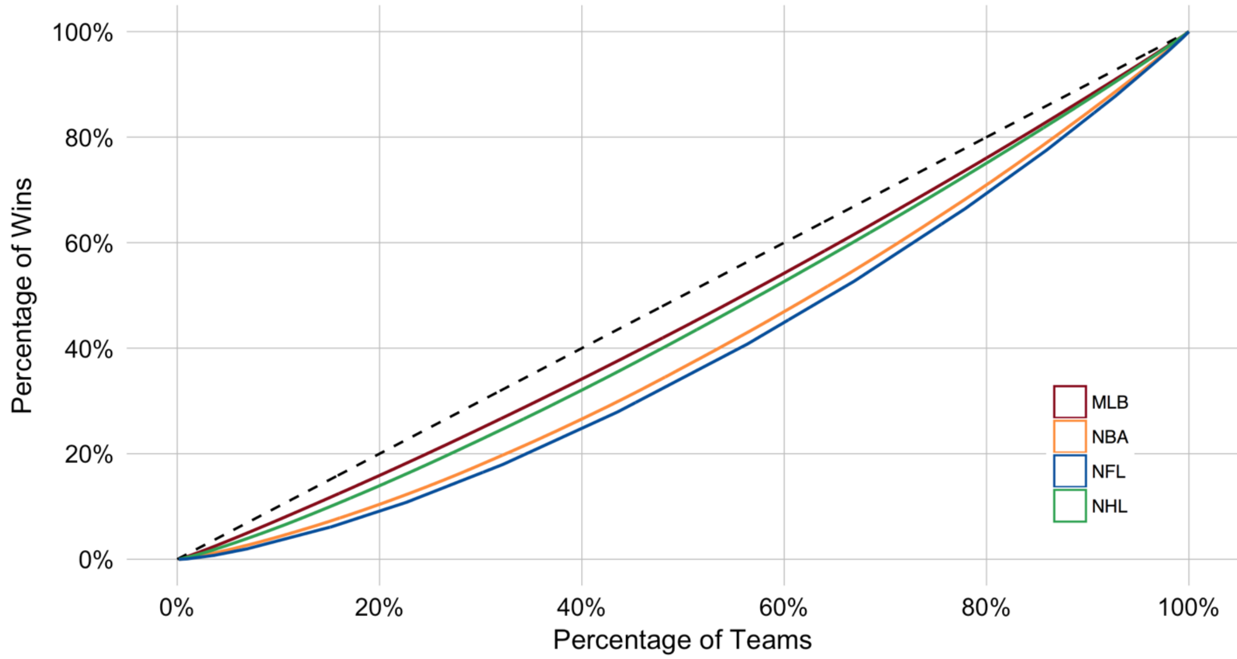

Figure 3. Lorenz Curve for regular season win totals from 1995 through 2015.

In summary, there are numerous ways to measure parity, but no single method is unilaterally superior. Rather, to fully examine the competitive landscape, it is important to consider both within-season balance and between-season balance. Across the various methods, the NBA showed the least parity, while the NFL tended to have the greatest balance, with the MLB and NHL generally residing in between. Across all sports, leagues are concerned about all these forms of competitive balance, since fan interest is impacted by it, which corresponds to attendance, television ratings, and league profits. Although by no means the sole explanation, it may be no coincidence that the league with the greatest parity (the NFL) is by far the most profitable, recording an operating income that was approximately $850 million higher than the three other leagues combined[8]. Succinctly stated, competitive balance is crucial to a league's ultimate success. Leagues have astutely recognized the importance of ensuring parity and have worked to implement various tools to provide a level playing field.

[8] Refer to Table 1 for additional league finance statistics. During the 2015 season, the NFL earned $2.92 billion in operating income, while the other three combined to account for $2.07 billion.

3.3. Salary Caps

One of the primary ways leagues try to increase parity is by implementing salary caps and other related payroll restrictions such as luxury taxes[9]. Leagues strive to maintain competitive balance, hoping for fewer contests where the winner can easily be predicted in advance. By limiting the amount of money a team can spend on players, leagues aim to reduce the difference in talent levels between low-spending and high-spending teams, with the objective of establishing a more equal playing field[10]. Since teams are located in different sized markets, ranging from desolate Green Bay (population 100,000) to dense New York City (population 8.4 million), there exists an inherent inequity between the amount of money a team can earn from its local market, which thereby affects how much money they have available to spend on players. Consequently, based in part on the premise that money can buy success, all leagues have implemented measures to reduce these core differences in available resources, whether that be a salary cap (NBA, NHL, and NFL) or a luxury tax (MLB and NBA). Salary caps set upper and lower limits to payrolls and are based on a percentage of qualifying league revenues (with definitions varying slightly by league), where owners are obligated to spend a defined share of the qualifying revenues. The NHL and NFL have a hard cap, which sets a firm limit and permits no exemptions. Meanwhile, the NBA utilizes a soft cap, which specifies a salary ceiling but allows many exceptions. There are dozens of exemptions, but the three most widely known are the Larry Bird Exception[11], the Rookie Exception[12], and the Mid-Level Exception[13] (Leeds and Allmen, 2011). For this reason, although the NBA does have a salary cap, the actual distribution of payroll more closely mirrors that of the MLB. As we can see, each league has implemented a unique infrastructure to control payroll disparities. Although they have achieved different levels of success in ensuring parity, it is important to keep in mind these critical structural differences throughout the entirety of this paper.

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[9] Additionally, salary caps also serve to limit team expenses, ensuring greater profitability for league members. While this is important to note, my paper focuses on its impact on competitive balance.

[10] Analogous to earlier discussions about the distribution of wins in between teams, refer to Appendix Figure A2 to see a Lorenz curve that displays how equal payroll spending was amongst each team during the 2015 season. Predictably, inequity was most significant in the MLB, while the two leagues with hard salary caps (NHL and NFL) were practically indistinguishable and displayed the greatest equity.

[11] Teams can re-sign a player who is already on its roster even if they surpass the cap.

[12] Teams can sign a rookie to his first contract even if they are already over the limit.

[13] Teams can sign one player to the league average salary even if they exceed the threshold.

3.4. Free Agency

While salary caps have changed immensely over time and vary greatly between leagues, the concurrent introduction and expansion of free agency has had a comparable (but opposing) impact. There is additional nuance, but free agency generally refers to ability of players (that are no longer under contract) to sign with any team that provides an offer. Before its advent, players routinely stayed with one team over the entirety of their career, since organizations retained nearly all market power and could employ players indefinitely. Although free agency has remained structurally similar over the period of analysis (all sports implemented free agency before 1995), it is important to understand this mechanism as it forms a key source of mobility between players and franchises, allowing players to seek "market rates" for their talent and creating liquidity in the labor market. The emergence of these competing forces has led to the development of a labor market where players often seek maximum compensation via free agency, while teams attempt to optimize the talent level of their player personnel within the confines of a salary cap. Across all sports, the labor market has trended towards increased fluidity, with the rise of free agency allowing players to change teams with greater ease. The increased mobility of players theoretically means that players are able to join teams where their abilities are most valued, allowing them to earn a higher salary. In practice, elite players command the highest salaries in free agency, with teams that are able to sign those players generally performing better.

Overall, these concepts are all imperative in understanding the underlying relationship between payroll and performance. In many instances, these dynamics interact with one another, confounding the ability to isolate individual factors. Nonetheless, one of the most fundamental takeaways of this section is the concept of competitive balance. Leagues are highly invested in ensuring parity, as their ultimate success is predicated on providing a relatively even playing field for all of its members. All four sports have instituted payroll restrictions as a tool to increase parity, and this balance can be measured in a variety of ways (including within-season, between-season, and graphically with Lorenz curves). Thus, given the importance of competitive balance, this paper frequently returns to the concept by connecting various key findings.

4 Data

In this section, I begin by reviewing the various data sources. Next, I provide introductory figures and discuss the unique relationship between payroll and performance in each league. Lastly, I explain some data transformations that I have made that are used in subsequent empirical analysis.

4.1. Discussion of Data Sources

Fortunately, strong popular interest in professional sports has prompted widespread research in the area. Rodney Fort, a prominent expert who has published extensive work on the intersection of economics and business in professional sports leagues, coincidentally undertook similar research when he examined the association between team payroll and winning percentages from 1990 to 1996, finding that the correlation was significant in the NHL and NBA, but not in the NFL or MLB (Quirk and Fort, 1999). Over the years, Fort has compiled a thorough and comprehensive database with a wide variety of data in his personal site (*Rodney Fort's Sports Business Data Pages*). On his website, Fort annually updates a massive repository which includes historical salaries, payrolls, and organization finances. Fort accumulates information from a variety of sources to develop a singular databank of what he claims to be "the most complete data on the economics and business of U.S. professional sports leagues in existence."

For financial information (which includes payrolls and team finances), Fort relies heavily on a few sources. A large swath of payroll data comes directly from a USA Today Index that documented team payrolls across the four professional sports leagues from roughly 2000 to 2010 (with more recent figures for certain leagues). For time periods before 2000, Fort cites other experts who have undertaken research in the area and collected payroll data based on their own proprietary methods. For seasons after 2010 (when the USA Today Index discontinued tracking payrolls), Fort cites a handful of league-specific sites that have documented payrolls. Additionally, Fort has recorded Forbes' financial estimates for every team in the four major leagues over the past 20 years, providing data on various factors including team valuations, revenues, expenses, and operating incomes. Altogether, Fort has compiled comprehensive team financial data for all four leagues from 1995 to 2015, which determines the scope of this paper.

For team performance metrics, Sports Reference LLC maintains and updates four separate websites for the respective sports leagues. The four websites maintain detailed records of each team's performance, chronicling individual game results for each team over the entirety of a franchise's existence. They cleanly summarize a variety of team performance metrics, logging records for regular season and postseason performance. Additionally, each sport's site includes additional metrics for a variety of league-specific factors. For instance, there is data for the MLB on runs-for versus runs-against, data for the NBA on offensive and defensive ratings, data for the NFL on yardage differential, and data for the NHL on strength of schedule. Although they are not completely uniform across leagues, prohibiting a universal comparison between sports, some of these additional metrics are present for all leagues, which I have used in some subsequent analysis.

Combined, the financial figures (drawn largely from Fort's repository) and team performance data (sourced from their respective reference sites) are merged into a comprehensive dataset, allowing the examination of a variety of exogenous and endogenous variables. That said, there are some inherent potential weaknesses. Namely, as evidenced by the significant amount of merging, the variety of data sources introduce multiple points of entry for the data to diverge in consistency. This is most prominent for the payroll data, since certain blocks of data come from different sources (individual experts, USA Today Index, and specific websites). While there is some limited concern about maintaining fidelity across all time periods for all metrics, this data has been vetted by one of the most prominent researchers in this field (Fort), instilling trustworthiness in the figures. Moreover, the differences in payrolls across years are less significant, since the empirical formula controls for year, which means that any potential variances in the data collection process are minimized. In sum, we should be confident that the core dataset has accurately curated information, providing credibility that the results are predicated on correct information.

4.2. Preliminary Baseline Analysis

To begin the comparison across leagues, I have created Figures 4-7 to illustrate differences between team payroll and performance for each sport. The teams are broken up into four quartiles based on their payroll ranking for a given year and have been sorted vertically, with *Quartile I* representing the biggest spenders. For each sport, the horizontal axis shows the different levels of advancement that teams can achieve (i.e. missed playoffs, reached first round, won title, etc.), and the size of the circle is weighted by the proportion of teams that fit that criteria. It is important to note that the circles represent a cumulative count of teams that progressed at least that far. For example, a circle in the *League Championship* column and the *Quartile IV* row represents the percentage of teams from the lowest payroll quartile that made it at least that far before being eliminated. As previously noted, I have arranged the sports in order of the restrictiveness of their salary caps, starting with the free-form MLB and finishing with the tightly regulated NFL. The following visualizations establish a baseline for the relationship between payroll and on-the-field performance, but are analyzed with greater granularity in subsequent sections.

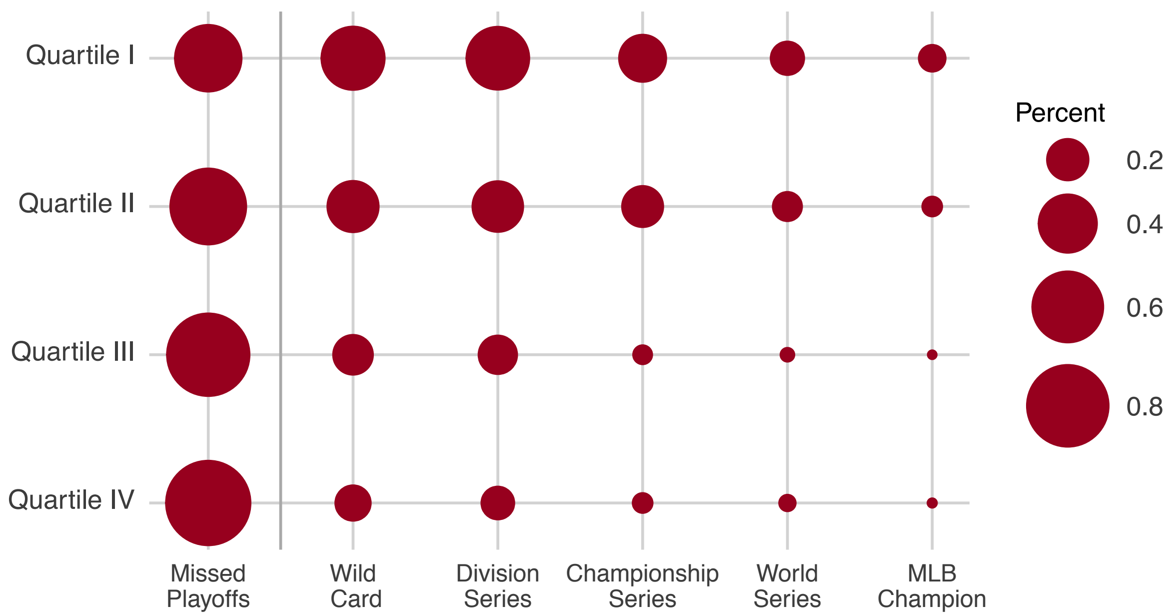

Figure 4. Percent of MLB teams from each *Quartile* that reach each round.

As the only league without a salary cap, the MLB shows one of the greatest disparities in team performance between above-average and below-average spending teams (Figure 4). When comparing quartiles, the top two appear to attain similar levels of postseason success (with evidence of slightly better performance for the highest quartile), while the bottom 50% of teams experience similar levels of playoff futility. The implications are that organizations that are willing and able to spend more than their peers are more likely to achieve matching success, while those unable to do so ultimately perform much worse. This can also be seen with regular season performance by examining the first column of Figure 4. There is a clear relationship between increased spending and higher odds of making the playoffs (almost 50% of *Quartile I* teams make the playoffs, while over 85% of *Quartile IV* clubs miss the playoffs), which could be explained by a couple of reasons. First, the MLB regular season is 162 games, nearly double that of the NBA and NHL (82 games each) and over 10 times longer than the NFL (16 games). Given the larger sample size, better teams have more opportunities to win (and show that they are superior), compared to shorter seasons where a few games have a much larger impact on overall performance. Next, the nature of baseball is that it is more of an individual sport that happens to be played within teams. Put differently, a baseball game is composed of a series of one-on-one matchups between a pitcher and opposing hitter, with limited team interaction throughout the majority of the game. This means that when a franchise acquires a player, they should have greater ability to project how that player impacts the game without having to worry as much with how they may affect other players through team dynamics. This is unique to baseball, as it further isolates the relationship between payroll and performance.

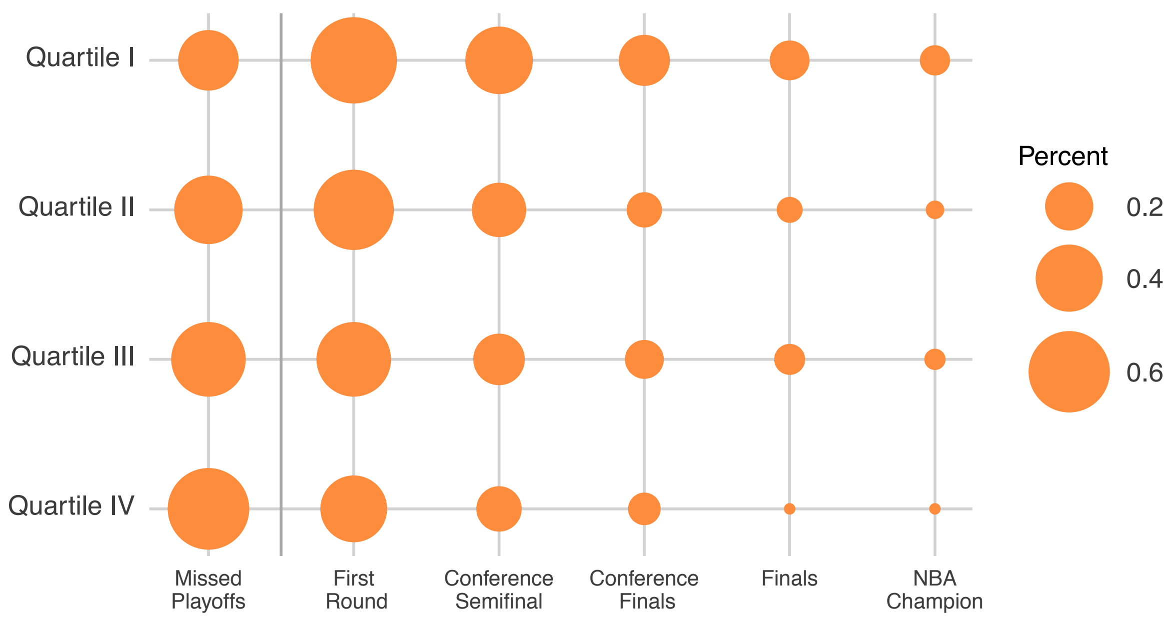

Figure 5. Percent of NBA teams from each *Quartile* that reach each round.

Exploratory analysis into the NBA highlights a few interesting observations (Figure 5). First, the proportion of teams reaching each end state noticeably varies across the quartiles. This suggests that payroll spending and team success are correlated, with varying degrees of spending associated with very different end state equilibrium. Next, comparing the proportion of teams that won the championship depicts how teams from the highest quartile were significantly more likely to win a title, while teams in the lowest quartile were very unlikely to win. This implies yet again that there is a difference in success achieved (as defined as winning the title) depending on a team's payroll. Third, the graphic appears to show that the middle 50% of teams (*Quartile II* and *Quartile III*) go on to achieve relatively similar levels of success. One potential interpretation is that teams in the middle of the payroll scale are fairly similar, compared to teams in the upper quartile that achieve much greater success and teams in the bottom quartile that attain much less success. As a whole, while these initial insights appear relatively straightforward and intuitive, it is important to note that these seemingly common-sense conclusions are supported by the data, providing evidence that these phenomena occur.

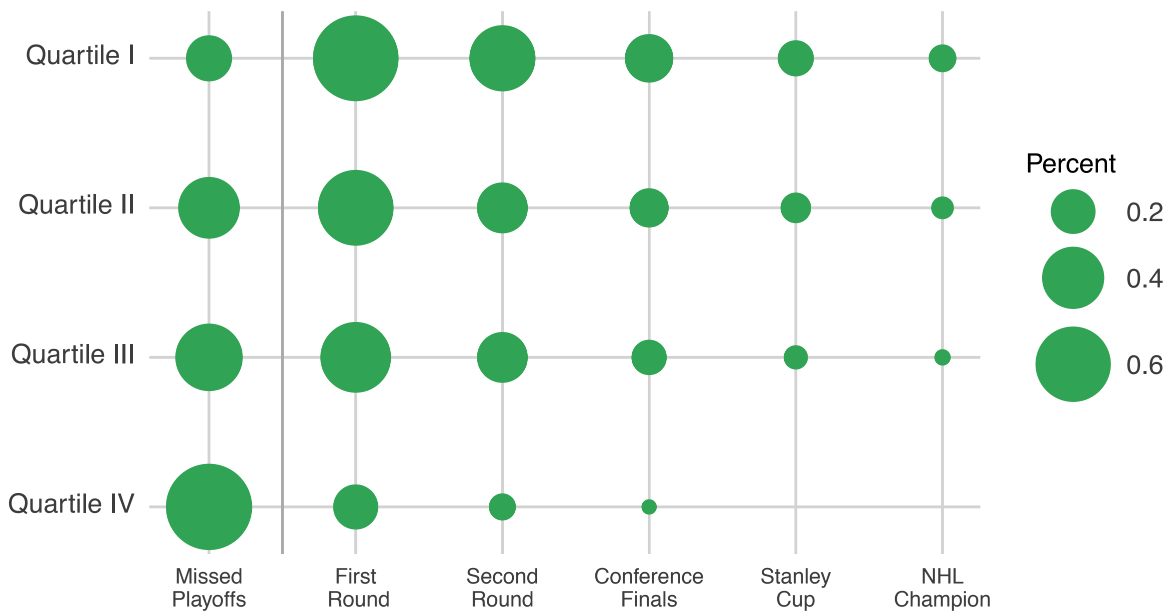

Figure 6. Percent of NHL teams from each *Quartile* that reach each round.

The association between payroll and performance in the NHL (Figure 6) seems to highlight a couple interesting relationships. First, the top three quartiles appear fairly similar, with the top quartile experiencing marginally greater postseason success. Notably, *Quartile IV* teams perform significantly worse, with the majority of these teams failing to make the playoffs. Secondly, when solely looking at regular season points percentage (defined as a team's points as a percent of the theoretical maximum, and represented by its inverse relationship with *Missed Playoffs* in Figure 6), there appears to be a very strong relationship with payroll. Each successively higher quartile makes the playoffs at a significantly higher rate, with approximately

80% of top-spending teams making the playoffs compared to just 20% of low-spending teams. The implications are that while payroll spending may be highly correlated with regular season performance, this relationship may degrade in the postseason.

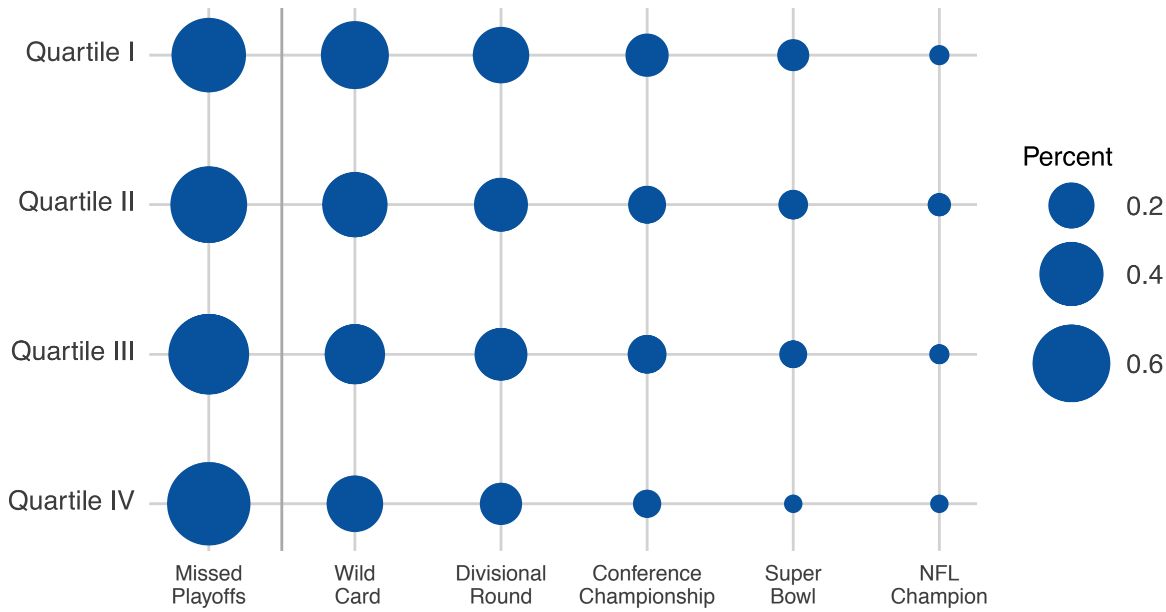

Figure 7. Percent of NFL teams from each Quartile that reach each round.

Unlike the other sports, the NFL appears to show that differences across payroll quartiles have very limited impact on team performance (Figure 7). Across all quartiles, teams appear to achieve playoff success at similar rates, suggesting that team payroll is not strongly related to performance. There are a few reasons why this may be the case. First of all, the salary cap severely constricts the range of payrolls, meaning that the difference between the lowest and highest spending teams may not be a very significant in real dollar terms. Secondly, the season only has 16 games and the playoffs are single-elimination, both of which are unique to football. This greatly increases the role of luck, since each regular season game has a larger impact on overall standings and playoff advancement is determined by a single game, rather than a larger sample size in which one would expect the better team to win more frequently. Lastly, the increased prevalence of injuries may introduce increased uncertainty in the relation between payroll and performance. In other words, a high-spending team could have a large number of expensive players injured at a given point in time, which means that the payroll associated with the players actually participating in the games may be significantly lower than total reported payroll. Unfortunately, data does not exist at a player by player level over the entire 20-year period (it is only available for a recent subset of seasons), prohibiting the ability to quantitatively control for the incidence of injuries. However, this is not a critical omission for a couple of reasons. One, injuries can be assumed to occur roughly randomly, so the exclusion is unlikely to systematically skew the results. More importantly, the focus of this paper is on whether the overall amount of money a team spends is associated with success, which is different than trying to determine if payroll-dollars on the field translates to improved team results. Therefore, future analysis in this paper does not control for the prevalence of injuries, as the data is not readily available and it is merely tangentially relevant to the intended research question.

Figures 4-7 provide an initial look into the relationship between payroll and performance. Broadly, baseball, basketball, and hockey all appeared to show a strong correlation between payroll and team result, while football teams across all quartiles seemed to achieve comparable levels of success. While by no means exhaustive, the two primary objectives of these graphics are to illustrate that there appears to be a connection between team payroll and the resulting performance and that this relationship differs by league. Both across quartiles and between sports, we can see that there appears to be a variety of differences. To undertake a more robust quantitative analysis, subsequent sections discuss additional empirical specifications.

As previously mentioned, Levin et al. (2000) proposed a methodology for measuring salary parity, allowing us to see the relative difference between the highest and lowest spenders. In Figure 8, I have plotted the average payroll of the highest quartile teams divided by the average payroll of the lowest quartile teams (as defined by amount spent on salary). A value of 2.0 would mean that on average, teams in the top quartile spent twice as much on players as teams in the bottom quartile, while a value of 1.0 would mean that the groups spent the same amount. As the graphic reveals, the MLB shows the greatest disparity, while the NFL had the smallest difference (with the NBA displaying slightly greater imbalance). Notably, the NHL appears to be similar to the MLB from 1995-2003, but then abruptly drops to more closely mirror the NBA and NFL from 2005-2015. This is due to fundamental change in their collective bargaining agreement after contentious negotiations led to the unprecedented cancellation of the 2004 season, ultimately causing the implementation of a salary cap from 2005 and onward. In this light, we can clearly see the impact that a salary cap has on a league’s payroll parity. In the unrestricted MLB, the highest spending teams tended to spend approximately 2.5 times as much as the lowest spending teams, by far the biggest discrepancy between low and high spenders across all sports. Conversely, the other leagues tended to see ratios around 1.5, underscoring a much smaller difference between the amount teams spent on salaries. The implications of these findings are significant. When revisiting Figures 4-7 with this knowledge in mind, we can begin to understand some rationale for why we have observed those results. For instance, the MLB showed the greatest difference in performance achieved by teams in the top versus bottom quartiles, but we now know that those teams spent appreciably different amounts of money on player salaries. On the other end of the spectrum, the NFL showed the greatest parity across all quartiles, but also had the smallest difference in dollar amounts between the top and bottom quartile teams. Put together, we can see that relationship between spending and results may be dependent upon the actual magnitude of payroll differences, rather than a team's nominal rank in salary. In other words, spending the 5th most compared to the 25th most on player salaries may be less important than the actual relative difference in dollar amount spent. The fact that *Quartile I* teams in the MLB performed much better than *Quartile IV* teams may be indicative that the teams from the respective groups spent tangibly different amounts, while extreme equity in the NFL could reflect the fact that the highest and lowest quartiles are actually spending a very similar total amount.

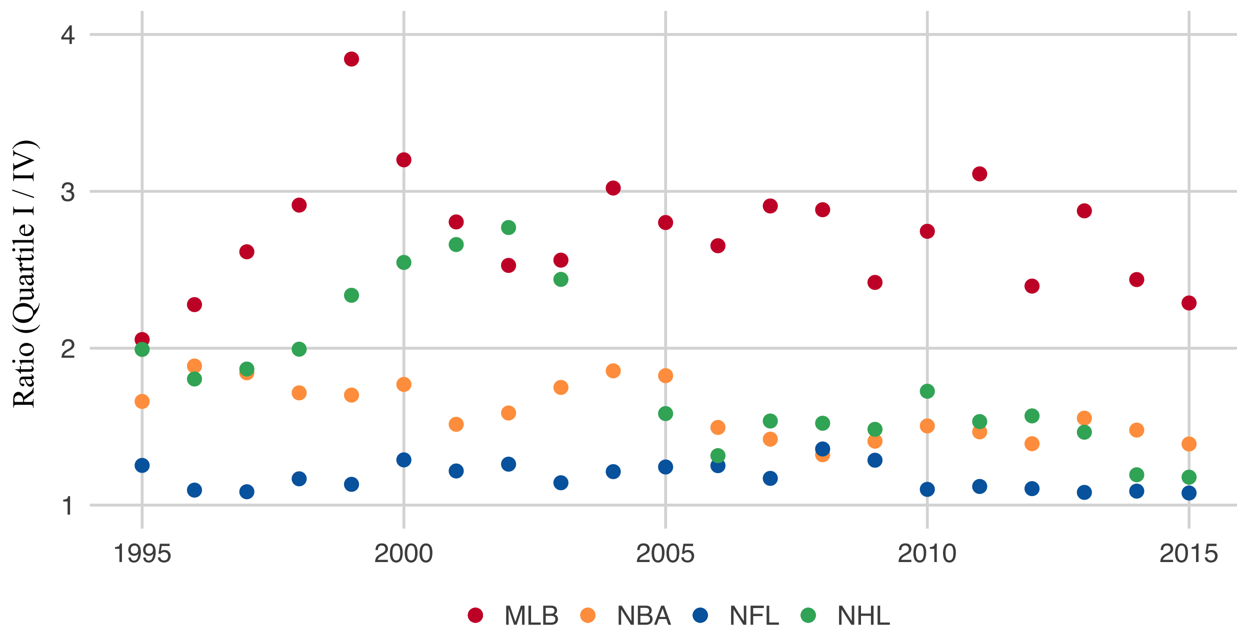

Figure 8. Payroll parity – average payroll of *Quartile I* clubs divided by *Quartile IV*.

4.3. Data Transformations

Although Figures 4-7 provide a useful baseline in understanding the relationship between payroll and performance in the four leagues, there are limitations to using quartile buckets. As discussed, the actual difference in amount spent appears to be a more important factor than a team's nominal ranking. Therefore, to retain the relative differences in payroll and allow for comparisons across years (and sports), I standardized payrolls by calculating:

$$ZScorePayroll_{it} = \frac{TeamPayroll_{it} - LeagueAveragePayroll_t}{StandardDeviationLeaguePayroll_t} \quad (8)$$

where $TeamPayroll_{it}$ is team *i*'s payroll in year t, $LeagueAveragePayroll_t$ is the average payroll for all teams in year *t*, $StandardDeviationLeaguePayroll_t$ is the standard deviation of team payrolls in year *t*, and $ZScorePayroll_{it}$ is the resulting z-score for team *i*'s payroll in year t. In Figure 9, we see that $ZScorePayroll_{it}$ appears to show a roughly normal distribution of values, providing justification for its appropriateness[14]. There is some minor high-end skewing in the MLB and NBA, but that is consistent with their salary cap structures that allow certain teams to spend very high amounts (versus the more constrictive NHL and NFL). Moving forward, all payroll calculations will use the standardized $ZScorePayroll_{it}$values, which both preserves relative payroll differences and allows for appropriate comparisons between sports and over the entirety of the period.

[14] Since all subsequent analysis uses the standardized payroll values, it is essential to understand how to calculate and interpret payroll z-scores. For illustrative purposes, consider the 2015 season for the Golden State Warriors. That year, the Warriors spent $93,707,197 on payroll compared to the league average of $78,434,503, while the standard deviation was $10,615,728. Thus, the payroll z-score was calculated as $ZScorePayroll = \frac{(93{,}707{,}197 - 78{,}434{,}503)}{10{,}615{,}728} = 1.44$. For interpretation, that means the Warriors spent 1.44 standard deviations above the league average.

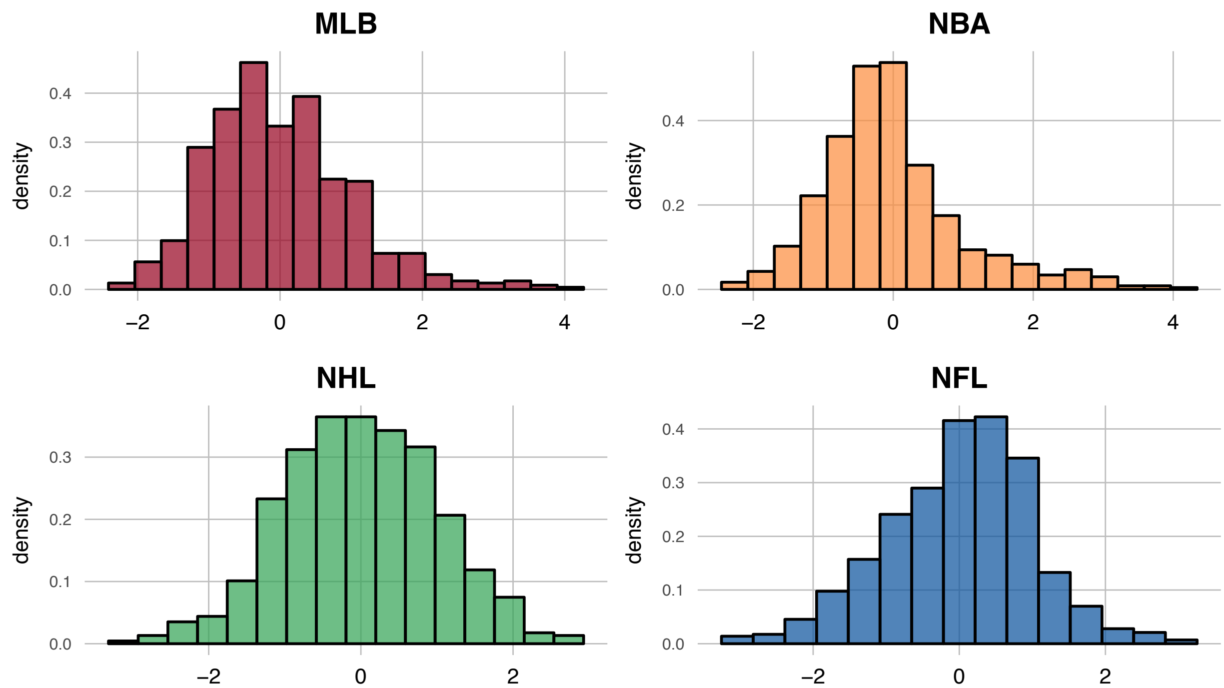

Figure 9. Histograms of payroll z-scores for each league from 1995 to 2015.

5 Empirical Analysis and Discussion

This research aims to examine regular season, postseason, and financial success. While by no means a comprehensive list of all the possible ways to judge a team's accomplishments, these represent three distinct and critical ways that organizations are evaluated. Beginning with regular season success, this paper will examine a few different metrics (including raw winning percentages, standardized winning percentages, and Simple Rating System values) to gauge how well a team performed throughout the season. Playoff achievement is also measured since many claim that the ultimate way to judge how well a season went is based on how they finish the season. Since titles are the core way of assessing postseason performance, this analysis will use championships to indicate a team's attainment. Lastly, given that professional sports are businesses, they can be evaluated based on their financial performance. Although many different metrics could be used to assess a team's financial performance, this paper has decided to focus on operating income[15]. In the appendix, I also discuss two additional metrics: whether a team qualified for the playoffs and the valuation ranking for each franchise[16].

Throughout the entirety of this empirical work, it is important to note that this research does not attempt to create an exhaustive model that tries to precisely predict a team's success. Rather, it attempts to show how the amount a team spends on its payroll is associated across the three dimensions of success, comparing these relationships between the four leagues. To comprehensively model a complex event (such as the likelihood of a team winning), most econometric analyses would likely include a vast swath of covariates. But since the focus of this paper is on the relationship between payroll and performance, I have only a limited amount of controls that I believe are essential. Most notably, many of the regressions include fixed effects[17] for each franchise, which is vital for understanding the underlying relationship. The inclusion of fixed effects allows the econometric model to control for idiosyncratic franchise differences that likely affect the underlying relationship between payroll and performance. These include a wide variety of team-specific factors such as coaching, training facilities, ownership priorities, and culture that would likely impact the results. In a perfect world, there would be quantifiable metrics for each of these influences, allowing us to see how they relate and interact with one another. Unfortunately, these are all mostly unmeasurable features that cannot be accurately quantified. In the absence of this data, I have grouped them together as franchise-level fixed effects to control for these distinctive factors, allowing us to more accurately examine the underlying relationship between payroll and performance[18].

[15] There are many other financial figures that team owners care about, most notably the valuation of their franchise. However, most team value estimates are at least in part based on a multiple of operating income, so they do not move independently. Moreover, operating income is more closely tied to the actual operations of a team (and therefore likely more directly impacted by the events in a season), while valuations tend to be based on a variety of factors that are not necessarily tied to team operations. Consequently, this research has chosen to focus on operating income as the metric of financial performance.

[16] Refer to the discussion that starts with Appendix Figure A12 for commentary on the relationship between payroll and performance for these two metrics, in addition to the rationale behind prioritizing the metrics included in the body of this paper.

[17] Essentially, fixed effects mean that we include a dummy variable in the regression for each franchise that holds constant (or "fixes") the effects across franchises that we cannot directly measure or observe. In this way, we can control for organization-specific factors and better isolate how changes in payroll are associated with various performance metrics. While is certainly not perfect since there have been many changes within organizations over the past 20 years (such as ownership, coaching, and location), its inclusion allows for a more informative analysis.

[18] See Appendix Figures A3-6 for plots of team-specific regressions for all franchises. These charts provide additional motivation behind the use of fixed effects, as we can see that the relationship between payroll and regular season winning percentage often differs by organization.

5.1. Regular Season Success

Prior research has almost exclusively focused on examining the relationship with regular season success, mostly looking at winning percentages. Given the larger sample size of games compared to the playoffs, the regular season may provide a more accurate picture of a team's abilities. To begin the exploration into the relationship between payroll and performance across three dimensions of success (regular season, postseason, and financial), I first analyzed the relationship between a team's payroll and their regular season performance. For illustrative purposes, Figure 10 provides an introductory depiction of this relationship. Each point represents a single season, the horizontal axis indicates payroll z-scores, the vertical axis notes winning percentages, and the solid line shows a simple linear regression[19]. While the respective slopes should not be directly compared (as discussed in-depth earlier and in-brief later), we can see that higher spending teams tended to have a better regular season winning percentage.

[19] It is important to note that Figure 10 does not include team fixed effects, but rather shows league aggregates. As a result, the empirical relationship may differ from this initial depiction after controlling for franchise factors.

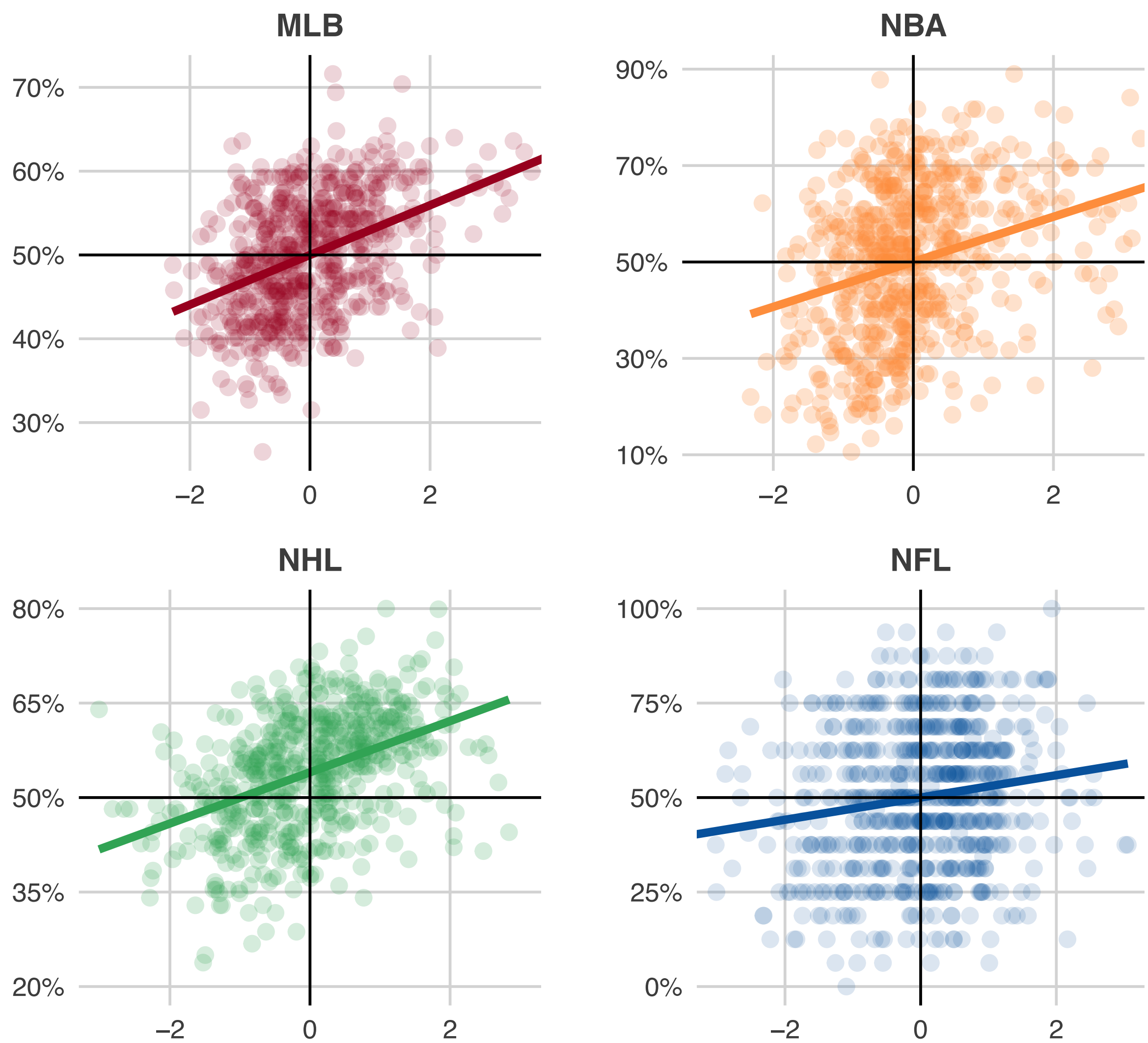

Figure 10. Payroll z-score versus regular season winning percentage.

The empirical analysis between payroll and regular season winning percentage starts with the following OLS regression:

$$WinPercent_{it} = \beta_1 PayrollZScore_{it} + FE_i + \varepsilon_{it} \quad (9)$$

where $WinPercent_{it}$ is calculated from a team's regular season results, $PayrollZScore_{it}$ represents the corresponding z-score for team i's payroll in year t, and FE_i represents fixed effects for each team (these regression results have been omitted from the summary tables since they have been included only as a control). Table 4 highlights the results, providing estimates and standard errors from the regression. Since the regression uses fixed effects for each team, one team must be omitted in order to serve as a baseline for the others, which means that the intercept value represents the expected performance of the omitted team (as opposed to the league average). As a result, I have omitted the intercept value from the regression summary tables for all models that include fixed effects. However, the estimate that is critically central to this paper is the estimate of the coefficient for the $PayrollZScore_{it}$ parameter. When examining these coefficients, we see values between 0.023 and 0.054. This indicates that when a given team ends up spending one standard deviation (which corresponded to $44.6 million in the MLB, $10.6 million in the NBA, $4.3 million in the NHL, and $17.2 million in the NFL during the 2015 season[20]) above the average payroll, they are expected to have a winning percentage that is between 2.3 and 5.4 percentage points higher than if they spent the league average. Over the course of an entire season, this equates to about approximately 4 additional wins in the MLB, 4.4 wins in the NBA, 5.9 points in the NHL, and 0.4 wins in the NFL. These estimates are all statistically significant, revealing a relationship between a team's payroll and their regular season performance, with increased spending associated with greater success across all leagues. In real terms, these results are very significant as well. In all four sports, league standings are often tightly contested, where each additional win can be very meaningful. For instance, during the 2015 NBA season, the difference in the Eastern Conference between the 3rd seeded Miami Heat and the 8th seeded Detroit Pistons (the last team to make the playoffs) was merely 4 wins (48 versus 44 wins). Since spending an additional standard deviation in salary is associated with 4.4 additional wins over the course of an 82-game NBA season, we can see that a team's decision on how much they want to spend can have significant implications. A similar exercise for the other three sports depicts a similar picture, where small differences in team performance result in large differences in league standings. During the 2015 MLB season, the top four teams in the American League Wild Card race (in which the top two finishers make the playoffs) were separated by only four games, and a total of seven teams were within eight games of one another. In the 2015 NHL season, the top five teams in the Western Conference were separated by just seven points, while seeds two through five in the Eastern Conference had a difference of four points. Lastly, during the 2015 NFL season, the top three teams (the Denver Broncos, New England Patriots, and Cincinnati Bengals) in the American Football League had identical records with 12 wins and four losses apiece. These examples were not deliberately handpicked out of the decades of data, but rather simply reflect standings from the most recent year that was included

[20] See Appendix Table A7 for a complete history of payroll standard deviations for each year included in this paper.

in the analysis. As is evident, league standings are often determined by narrow margins, meaning each additional win can have a substantial impact on a team's ranking.

Table 4 – *Winning Percentage = $\beta_1 PayrollZScore_{it}$ + Team Fixed Effects*

	(1) **MLB**	(2) **NBA**	(3) **NHL**	(4) **NFL**
Payroll Z-Score	0.023*** (0.004)	0.054*** (0.007)	0.036*** (0.004)	0.026*** (0.007)
R^2	0.269	0.260	0.289	0.188
Observations	624	621	583	661

Note. NHL uses points-percentage (points divided by maximum points) instead of regular season winning percentage. *** p-value <0.001, ** p-value <0.01, * p-value <0.05. Standard errors are denoted in parentheses.

One limitation of the results presented in Table 4 is that the coefficient for the payroll z-score variable is hard to compare across sports, since the distribution of winning percentages greatly differs by sport[21] (i.e. most MLB teams have winning percentages between 40% and 60%, whereas NFL teams tend to be dispersed from 20% to 80%). The issue is that when comparing across leagues, increasing a team's winning percentage by 2.5 percentage points is much more meaningful in the MLB than it is in the NFL because team results are more tightly clustered in baseball. Thus, in order to better discern the relative impact that spending has on a team's performance, I ran the following regression:

$$WinZScore_{it} = \beta_1 PayrollZScore_{it} + FE_i + \varepsilon_{it} \qquad (10)$$

where all terms are the same as Equation 9, except winning percentages have been converted into z-scores[22] (denoted by the variable $WinZScore_{it}$, it has been calculated with the same method as $PayrollZScore_{it}$, which is described in Equation 6). The results summarized in Table 5 underscore the relative impact that spending has in each league. The coefficients for payroll z-score are all statistically significant again, but this time we can see that the impact of additional spending is less than half as impactful in the NFL as it is in the three other leagues. This conclusion supports the notion that spending in football does not yield as high returns (in terms of regular season performance) as it does in the other sports. Put differently, while spending

[21] See Appendix Figure A8 to see the distribution of winning percentages in each league. As discussed in Section II, the dispersion of winning percentages is partially a function of the number of games played in a season rather than an indicator of parity.

[22] See Appendix Figure A9 for histograms of the Winning Percent Z-scores in each sport. As expected, they all appear to be approximately normally distributed.

more money in the NFL does tend to increase a team's regular season winning percentage, it does not increase as meaningfully as it does compared to the MLB, NBA, and NHL.

Table 5 – *Z-Score Winning Percentage* = $\beta_1 PayrollZScore_{it}$ + *Team Fixed Effects*

	(1) MLB	(2) NBA	(3) NHL	(4) NFL
Payroll Z-Score	0.335***	0.345***	0.378***	0.138***
	(0.055)	(0.042)	(0.044)	(0.035)
R^2	0.269	0.260	0.311	0.188
Observations	624	621	583	661

Note. *** p-value <0.001, ** p-value <0.01, * p-value <0.05.

To provide additional information about team performance, statisticians have derived a large number of advanced metrics that attempt to discern a team's "true" ability[23]. One such metric that is widely used is called the Simple Rating System (SRS), which yields an easily interpretable value for measuring how good (or bad) a team is by revealing how many units (i.e. runs, points, or goals) a team is better (or worse) than the league average[24]. For instance, the 2015 Golden State Warriors had an SRS of 10.38, meaning they were 10.38 points better than the average NBA team that year. The units depend on the sport, as it is denoted in runs in the MLB, points in the NBA and NFL, and goals in the NHL. Rather than examining a team's wins and losses, SRS takes into account a team's strength of schedule and average score differential. Although it is highly correlated with a team's winning percentage[25], it tries to more accurately describe a team's abilities. Using SRS figures in place of winning percentages, I ran the following regression:

$$SRS_{it} = \beta_1 PayrollZScore_{it} + FE_i + \varepsilon_{it} \tag{11}$$

where SRS_{it} represents the corresponding SRS value for team *i* in year *t*. When reviewing the results in Table 6, we can see that the model has improved its explanatory power, as the r-squared values have increased for all leagues. Although we cannot directly compare the

[23] There are many other popular advanced metrics that attempt to discern a team's true strength. Some of the notable ones includes *FiveThirtyEight*'s ELO Ratings, Ken Pomeroy's college basketball ratings, and Bill James' Pythagorean win-loss expectation. SRS was chosen for this research because it exists for all sports, explicitly controls for margin of victory and strength of schedule, and has easier interpretation.
[24] See Appendix Figure A10 for histograms of the SRS values for each sport.
[25] See Appendix Table A11 for the regression comparing SRS values versus winning percentages. As expected, the r-squared values are all high (ranging from 0.770 to 0.941). Examining the coefficients, we see that an additional unit increase in a team's SRS value equates to a winning percentage that is 9.3 percentage points higher in the MLB, 3.4 percentage points higher in the NBA, 17.5 percentage points higher in the NHL, and 2.7 percentage points higher in the NFL.

coefficient estimates, since a run in baseball is not the same as a point in basketball, we can see that there is a positive association between a team's payroll and their SRS figure for that year. When using this advanced metric that attempts to better capture a team's strength, we see that payroll is even more significant than the raw winning percentages indicated. After controlling for margin of victory and strength of schedule, SRS provides a more representative measure of how well a team performed than their win-loss record, in which they could have had many close games where they were lucky (or unlucky) and narrowly won (or lost). Thus, the positive relationship between team payroll and SRS provides additional evidence that additional spending results in a stronger team, further reaffirming the earlier conclusion that indicated that organizations that decide to spend more on players tend to have better teams.

Table 6 – *Simple Rating System* = $\beta_1 PayrollZScore_{it}$ + *Team Fixed Effects*

	(1) MLB	**(2) NBA**	**(3) NHL**	**(4) NFL**
Payroll Z-Score	0.191*** (0.036)	1.538*** (0.190)	0.172*** (0.022)	0.852*** (0.218)
R^2	0.284	0.266	0.305	0.195
Observations	624	621	583	661

Note. *** p-value <0.001, ** p-value <0.01, * p-value <0.05.

Overall, all three regressions show a statistically significant relationship between payroll and regular season performance across all four leagues. This is consistent with previous studies on the MLB which found that higher spending was correlated with a better winning percentage. Since team standings are often tightly contested, small differences in winning can make a very meaningful impact in the bigger picture. For franchises that are committed to winning, it seems clear that spending more on team payroll can be an important step. However, when comparing across leagues, the coefficients on the untransformed winning percentages cannot be compared since the relative impact is not uniform. The conversion to use a team's winning percentage z-score allows us to contrast the estimates, revealing that the effect of additional spending in the NFL is less impactful than in all the other leagues, supporting the premise that parity is greatest in the NFL. When we used an advanced metric (SRS), r-squared values increased across all sports, offering further evidence that money has an impact on a team's regular season performance.

5.2. Postseason Success

Teams are frequently judged by their postseason accomplishments, so it is important to explore if team payroll is associated with greater success. To illustrate this relationship, Figure 11 highlights the amount each champion has spent[26]. The vertical axis shows payroll z-scores, the horizontal axis demarcates each year, and the league champion is depicted by the colored dot (while all other teams are in gray). In the MLB, 18 of the 21 World Series have been won by teams with above average payrolls. The NBA shows a little more variation, as the majority of champions have spent above average while a handful have spent slightly below. In the NHL, almost every Stanley Cup winner has spent above average. Lastly, consistent with many previous findings, the NFL shows the greatest balance with a more equal distribution of Super Bowl titles across various levels of payroll spending. As these charts depict, there appears to be a variety of relationships between payroll and winning the championship across the leagues, with the most striking positive association in the NHL and the greatest equity in the NFL.

[26] Analogous to Figure 10, it is worth noting that Figure 11 does not reflect team fixed effects, and simply rather shows league aggregates. For this reason, when controlling for franchise factors, the empirical relationship may diverge from this initial depiction. Nonetheless, Figure 11 aims to provide a helpful overview for the reader to reference.

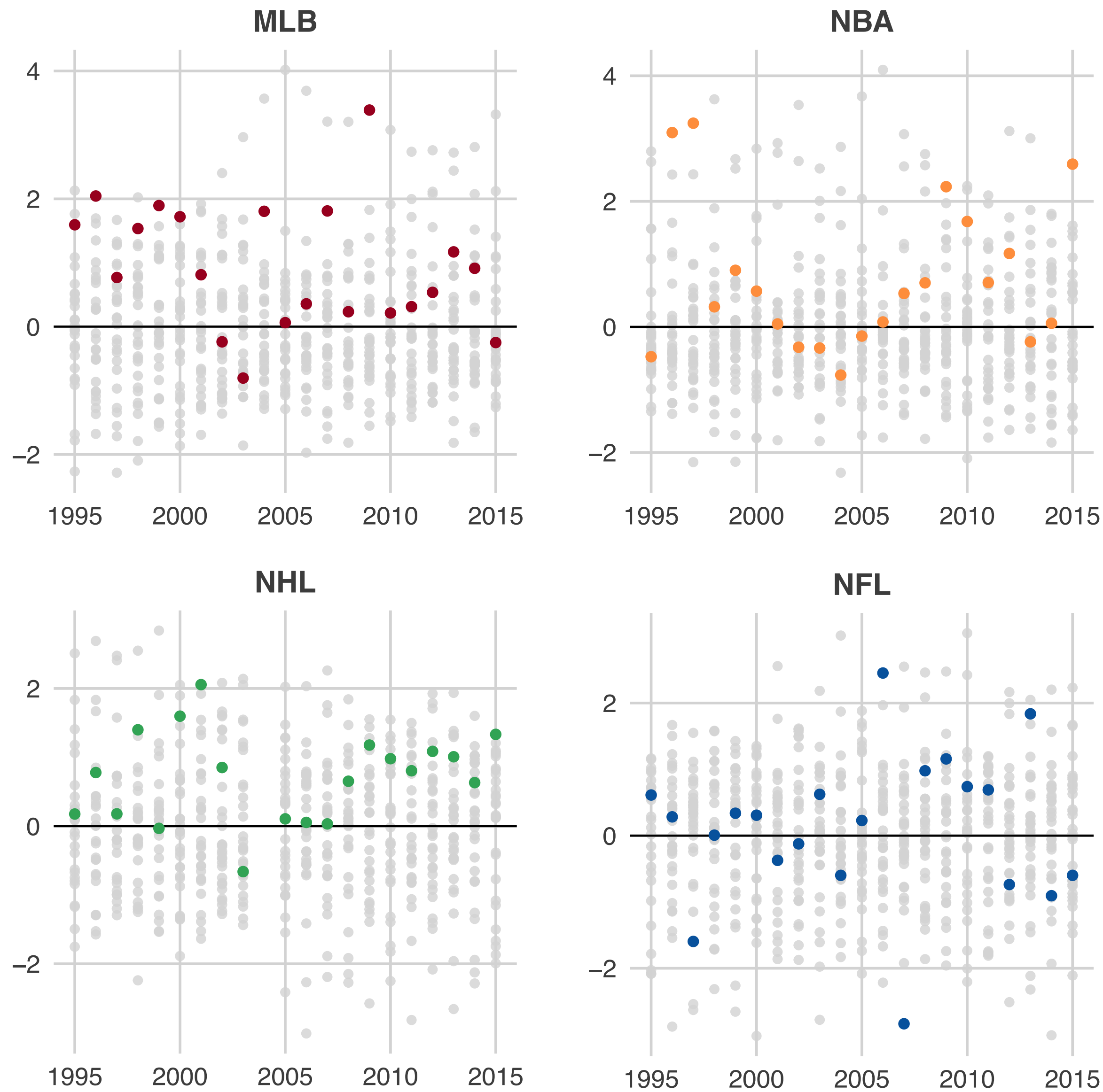

Figure 11. Payroll z-score values of championship winning teams (denoted by colored dots).

To empirically analyze this relationship, I computed the following logistic regression:

$$Championship_{it} = \beta_1 PayrollZScore_{it} + FE_i + \varepsilon_{it} \tag{12}$$

where $Championship_{it}$ is an indicator variable that denotes if a team won a title (taking a value of "1" if a team wins and "0" otherwise), $PayrollZScore_{it}$ represents the corresponding z-score for team i's payroll in year t, and FE_i represents fixed effects for each team. Since championships have been coded as either 0 or 1, a logistic regression is more appropriate than a simple OLS. The results summarized in Table 7 show that the relationship between payroll and title attainment is only statistically significant in the NBA and NHL. Since it is a logistic regression, the values of the coefficients cannot be interpreted directly from the regression output. However, we can calculate the odds-ratio, which tells us how much an increase in payroll increases the likelihood of a team winning. For the two sports that revealed a statistically significant positive relationship between payroll and championship attainment (NBA and NHL), the odds-ratio is approximately two. Ceteris paribus, this suggests that NBA and NHL teams are about twice as likely to win the championship when they increase their spending by a standard deviation. Although baseline odds of winning[27] are only about 3.3%, the effect compounds, meaning that a team that spends two standard deviations above the mean is about four times as likely to win the title than if they had spent the average amount. This means that if an average spending team's odds of winning are 3.3%, spending one standard deviation above the mean raises that to 6.6%, and two standard deviations results in another jump to 13.2%. This suggests that there is a meaningful relationship between payroll and title attainment in the NBA and NHL, with additional spending drastically improving the likelihood of winning the championship.

Table 7 – *Logistic Regression: Championship =* $\beta_1 PayrollZScore_{it}$ *+ Team Fixed Effects*

	(1) MLB	**(2) NBA**	**(3) NHL**	**(4) NFL**
Payroll Z-Score	0.464	0.729**	0.654*	0.098
	(0.379)	(0.270)	(0.317)	(0.243)
Payroll Odds-Ratio	1.590	2.072**	1.924*	1.103
Pseudo R^2	0.322	0.419	0.319	0.284
Observations	624	621	583	661

Note. Pseudo R^2 calculated using Cragg & Uhler's (also called Nagelkerke's) methodology. *** p-value <0.001, ** p-value <0.01, * p-value <0.05.

Although the inclusion of team fixed effects allows us to control for a variety of franchise-specific factors that are important, yet hard to measure, such as quality of management and team culture, it also partially obscures the bigger picture. When they are included, the interpretation of the coefficients tells us when team *i* spends more money on players, their success is expected to change by that amount. When the fixed effects are removed, we ignore each teams' dynamic changes in payroll and instead solely look to see if high-spenders perform better the low-spenders. In other words, we simply examine if bigger payrolls are associated with

[27] Since only one team per year wins the championship, the expected likelihood of a team winning is one divided by the number of teams. There are roughly 30 teams in each league (a few new teams have joined each league since 1995), meaning that the baseline odds of winning are approximately $1/30 \approx 3.3\%$.

greater success, rather than what to expect if a given team increases their payroll spending. Therefore, I ran the following logistic regression:

$$Championship_{it} = \alpha + \beta_1 PayrollZScore_{it} + \varepsilon_{it} \tag{13}$$

where everything is the same as Equation 12, except that team fixed effects have been removed. When reviewing the regression results in Table 8, we see that team payroll has a statistically significant positive relationship on championship attainment in the MLB, NBA, and NHL. Interestingly, estimates for the NBA and NHL remain fairly similar to previous results, but the MLB sees a noteworthy shift from insignificance to statistically significant. Again, the odds-ratios are approximately two, meaning that teams that spend one standard deviation above the mean are about twice as likely to win as if they had spent the league average. That said, the discrepancy between the estimate for the MLB with and without team fixed effects warrants additional explanation. Since the relationship was found to be insignificant when including fixed effects, and statistically significant when excluding them, that means that there was important explanatory information contained in the fixed effects for each franchise. With their removal in Equation 13, their impact was at least partially absorbed by coefficient for payroll z-score. In other words, franchises appear to be more significant in the MLB, with greater persistence of team result, regardless of how much they decide to spend in a given year.

Table 8 – *Logistic Regression: Championship =* $\alpha + \beta_1 PayrollZScore_{it}$

	(1) **MLB**	**(2)** **NBA**	**(3)** **NHL**	**(4)** **NFL**
Intercept	-3.673*** (0.275)	-3.537*** (0.254)	-3.603*** (0.282)	-3.424*** (0.223)
Payroll Z-Score	0.770*** (0.184)	0.584*** (0.174)	0.766** (0.241)	0.122 (0.219)
Payroll Odds-Ratio	2.160***	1.792***	2.151**	1.130
Pseudo R^2	0.101	0.062	0.070	0.002
Observations	624	621	583	661

Note. *** p-value <0.001, ** p-value <0.01, * p-value <0.05.

In sum, we see that when controlling for team-specific factors, there is a statistically significant relationship in the NBA and NHL between spending and a team's odds of winning the championship, while no such relationship existed in the MLB and NFL. Each additional payroll standard deviation is associated with a twofold increase in the likelihood that a team wins a title. When we remove team fixed effects, the MLB joins the NBA and NHL in having a similar statistically significant relationship between payroll and playoff performance. The large difference in results in the MLB when comparing with and without team effects is likely due to a combination of both the persistence of team results as well as an increased importance of franchises and their explanatory power on team results. Yet again, the NFL appears to have the greatest competitive balance, with all the other leagues showing a stronger connection between spending and performance.

5.3. Financial Success

Professional sports are a multi-billion-dollar business, so this analysis would be remiss to exclude an evaluation of teams' financial performance. There are a variety of metrics to select from, including annual revenues and team valuations, but operating income is the most appropriate since it accounts for both revenues and costs, and the figures are closely tied to a club's yearly performance. To depict this relationship, Figure 12 compares team payroll z-score and operating income (in $ millions)[28]. Charts for the MLB, NBA, and NFL appear to show a negative association between payroll spending and operating income. This suggests that the return on investment is negative, meaning the incremental revenue does not offset the direct expenses. Curiously, the NHL initially shows a positive relationship, with higher payrolls associated with greater operating income. However, these graphs are unable to show fixed effects, so they are less robust than subsequent analysis that controls for team-specific factors. Given the shifting financial landscape (including changes in their national and regional media deals, collective bargaining agreements, as well as general economic conditions), additional quantitative measures are needed to control for these changes over time. Analogous to team-specific factors, many of these temporal factors are hard to accurately measure, so I have included fixed effects for each year in subsequent regressions.

[28] Analogous to Figure 10 and 11, Figure 12 does not reflect team fixed effects and simply shows league aggregates.

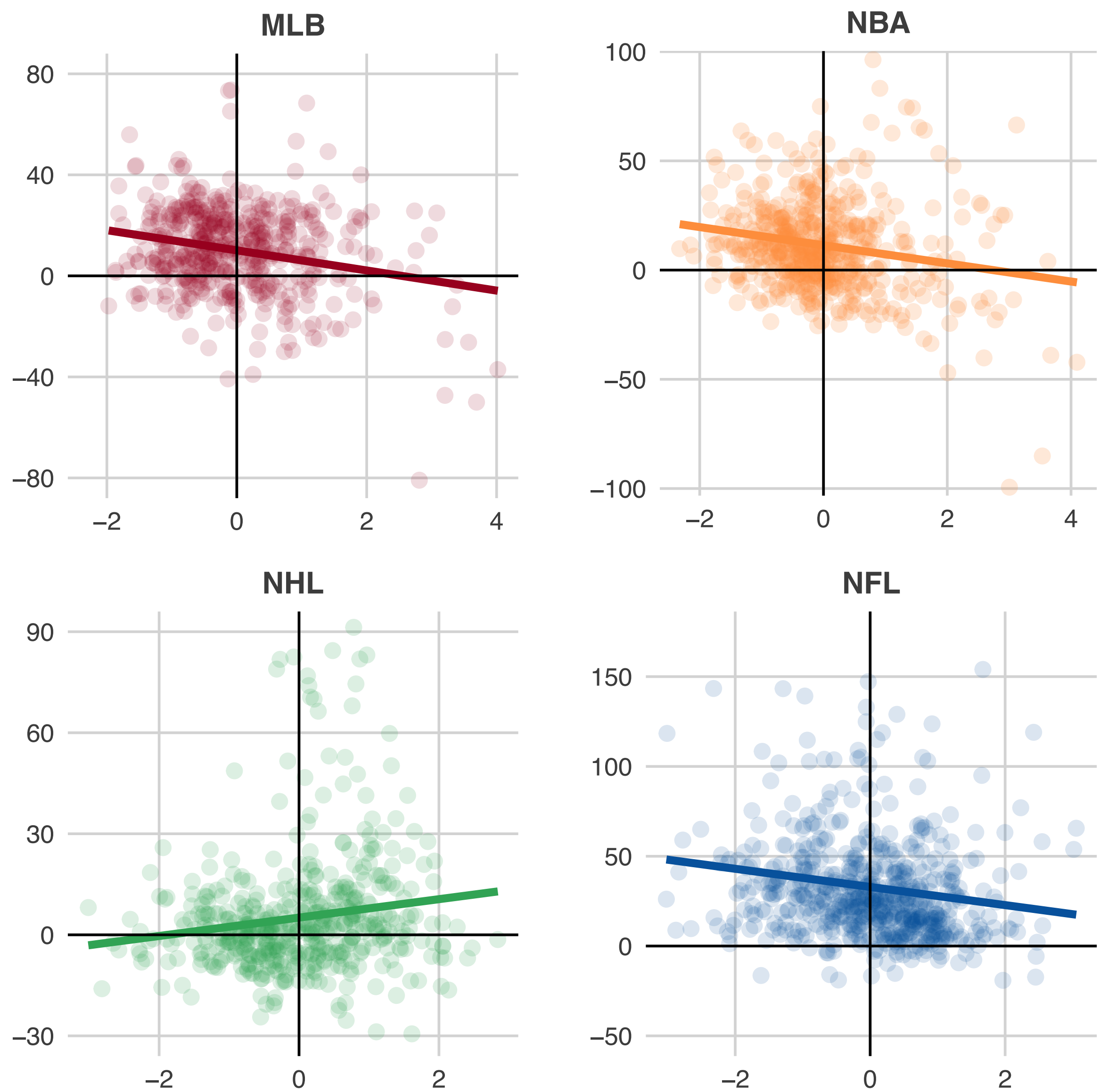

Figure 12. Payroll z-score versus operating income (in $ millions) from 1995 to 2015.

To examine the relationship between payroll and performance from a financial perspective, I computed the following regression:

$$OperatingIncome_{it} = \beta_1 PayrollZScore_{it} + FE_i + FE_t + \varepsilon_{it} \quad (14)$$

where $OperatingIncome_{it}$ is Forbes' estimate of team *i*'s operating income (in millions of dollars) in year *t*, $PayrollZScore_{it}$ describes the corresponding z-score for team *i*'s payroll in year *t*, FE_i represents fixed effects for each team, and FE_t represents fixed effects for each year. We can see the summarized results in Table 9, which show a statistically significant negative relationship between payroll and operating income across all four sports. This implies that when a team increases their payroll spending by one standard deviation, their operating income on average falls between \$2.2 million and \$9.8 million. One natural explanation is that since operating income has been defined as revenues minus expenses, an increase in costs (i.e. team payroll) will have a direct negative impact on the overall profit equation. When comparing the magnitude of these values with their standard deviations[29], we see that the drop in operating income tends to be smaller than the size of the standard deviation. In other words, as payrolls increase in size, revenue also tends to rise, but not significantly enough to offset the direct costs. This further supports the decision to focus on operating income (rather than solely revenue), since it allows us to see the net effect of both revenues and expenses. From this perspective, it appears that franchises may be faced with a decision between spending a lot of money on payroll in hopes of winning or optimizing costs to maximize profits.

Table 9 – *Operating Income (\$ Millions) =* $\beta_1 PayrollZScore_{it}$ *+ Team Fixed Effects + Year Fixed Effects*

	(1) MLB	**(2) NBA**	**(3) NHL**	**(4) NFL**
Payroll Z-Score	-3.121**	-9.821***	-2.160***	-6.494***
	(1.147)	(0.747)	(0.629)	(0.900)
R^2	0.367	0.684	0.646	0.648
Observations	480	534	530	631

Note. *** p-value <0.001, ** p-value <0.01, * p-value <0.05.

To better assess this potential competing goal, it is useful to see how profits change based on how frequently a team wins during the regular season. Since fans likely are more excited about a team when they are having a good year (and thus more likely to attend games), this could drive ticket sales and boost the revenue side of the profit equation. Thus, I ran the following regression:

$$OperatingIncome_{it} = \beta_1 PayrollZScore_{it} + \beta_2 WinZScore_{it} + FE_i + FE_t + \varepsilon_{it} \qquad (15)$$

where $WinZScore_{it}$ represents the standardized winning percentage of team *i*'s regular season winning percentage in year *t*. In Table 10, we see that while payroll has a statistically significant negative relationship with operating income in all four sports, winning in the regular season has a positive correlation in the MLB, NBA and NHL. When comparing the results with those in Table 9, a couple of factors strengthen the credibility of the refined model. First, the payroll z-score

[29] Refer to Table A7 in the Appendix for the historical records the standard deviation of each league's salary spending over the course of my study. For example, a typical standard deviation in the NHL is approximately \$8 million, compared to the *Payroll Z-Score* coefficient estimate of -\$2.160 million.

coefficients for all leagues become slightly larger in magnitude (i.e. more negative), which provide evidence that it is important to discern how much a team wins. Second, r-squared values increase for all sports, offering additional support that the relationship is more accurately measured when we control for winning. This follows intuition, since teams that win a lot would seem to be more exciting for fans, resulting in greater interest in the club. From an economic perspective, the increased demand is good news for a team's profitability, which could stimulate a variety of outcomes including higher attendance figures, raised ticket prices, or a jump in television viewership (resulting in more favorable television deals), all of which can help boost the bottom line for franchises. A primary reason why the NFL does not show a statistically significant positive association between winning and operating income is likely due to its revenue sharing agreement. Compared to the other three leagues, teams in the NFL share the highest amount of their revenues (61% of all revenue is shared in the NFL, by far the highest percentage). This works twofold, since not only do teams have to directly share the majority of the revenue that they earn, but they indirectly also have less of an incentive to generate revenues because they know they will only keep a small portion. To understand how team payroll, winning, and operating income are all interconnected, we need to understand the marginal impacts. Using the NHL as an example, Table 10 suggests that a one-unit increase in payroll z-score (typically around $8 million in the NHL) is associated with a drop in operating income of $2.68 million (all else equal). However, as summarized earlier in Table 5, we also saw that each incremental payroll standard deviation was associated with an increase in a team's win percent z-score by 0.378 units. Thus, combining those two findings, the expected decrease in operating income after considering the total net effect is $2.2 million (which is the result from calculating: -2.676 + 1.243*0.378)[30]. When reevaluating the potentially competing goals an organization may have in trying to win versus maximizing profit, an interesting dynamic appears. As teams increase payroll spending in the hopes of improving their roster, the drop in operating income can be partially offset if the money spent on players translates into wins.

[30] The equivalent calculation for the MLB yields -$3.1 million (-3.583 + 1.313*0.335) and the analogous procedure for the NBA returns -$9.9 million (-11.037 + 3.238*0.345). This means that an increase in a team's payroll z-score is expected to decrease operating income by those amounts.

Table 10 – *Operating Income ($ Millions) =* β_1*PayrollZScore*$_{it}$ + β_2*WinZScore*$_{it}$ *+ Team Fixed Effects + Year Fixed Effects*

	(1) **MLB**	**(2)** **NBA**	**(3)** **NHL**	**(4)** **NFL**
Payroll Z-Score	-3.583**	-11.037***	-2.676***	-6.643***
	(1.176)	(0.780)	(0.680)	(0.912)
Win Z-Score	1.313*	3.238***	1.243*	0.979
	(0.771)	(0.710)	(0.636)	(0.969)
R^2	0.371	0.697	0.649	0.649
Observations	480	534	530	631

Note. *** p-value <0.001, ** p-value <0.01, * p-value <0.10.

Altogether, we see that there is a statistically significant negative relationship between a team's spending on payroll and their operating income across all four league, which is consistent with findings from previous research (although that was focused solely on the MLB). In other words, from a financial perspective, there is a negative return on investment when spending additional money on players. To some degree, this follows intuition, since increasing player expenses directly reduces profits. That said, we are then confronted with a competing goal: should teams prioritize winning or profits? To better discern the underlying relationship, I ran a regression on Equation 15, which accounts for each team's regular season winning percentage (by using the standardized variable *Win Z-Score*). From there, we saw that winning had a positive relationship on operating income, which was statistically significant in the MLB, NBA and NHL. This also seemed logical, since teams that won more frequently likely tend to be more entertaining for fans, allowing franchises to profit from this additional consumer demand. At first glance, these results seem to conflict. On one hand, payroll spending leads to lower financial performance. On the other hand, earlier regression results revealed an association between payroll and winning percentages, while results from Equation 15 showed that winning was associated with greater profits. To reconcile this difference, it is important to examine the magnitudes of the coefficients summarized in the regression results. After accounting for the full net effect, we saw that winning in the MLB, NBA, and NHL partially offsets the drop in operating income. When additional payroll spending translates to improved regular season performance, teams recognize a higher operating income. However, if incremental payroll expenses do not lead to a higher winning percentage, then teams directly incur the additional outlay but do not receive the benefit of having a winning team, resulting in an even lower operating income.

5.4. Statistical Comparison Between Leagues

Up to now, the comparisons between leagues have largely centered upon examining differences in the parameter estimates. This has been done to make interpretation more straightforward, allowing us to see how changes in payrolls were associated with different levels of success in each sport. However, this approach did not tell us if the apparent differences were statistically significant. Many of the metrics (including raw winning percentages, SRS figures, and operating incomes) take unique values in each sport, but fortunately some of them are consistent across leagues. Namely, we can directly compare *Win Percent Z-Score*, *Playoffs* (an indicator variable that takes the value "1" if a team makes the playoffs and is "0" if they do not), *Championship* (an indicator variable that takes the value "1" if a team wins the title and is "0" if they do not), and *Valuation Rank*[31]. To examine if the leagues statistically differed from one another, I ran the following:

$$ResponseVariable_{it} = \beta_1 PayrollZScore_{it} + \beta_2 PayrollZScore_{it} * NBA + \beta_3 PayrollZScore_{it} * NHL + \beta_4 PayrollZScore_{it} * NFL + FE_i + \varepsilon_{it} \quad (16)$$

where separate regressions were run for the four comparable response variables and *NBA*, *NHL*, and *NFL* are all indicator variables that take the value "1" if the data came from the respective league. In Table 11, we can see the results from each model. It is important to note that one of the leagues must be omitted in order to run the various interactions, which in this case was chosen to be the MLB. Thus, when examining the coefficients of the interaction terms, their statistical significance is interpreted in comparison with the baseline team[32]. For the first two models (*Win Percent Z-Score* and *Playoffs*), we see that the relationship between payroll and those two variables is statistically significantly lower in the NFL, meaning that money does not have as much of an impact. The third model (which looks at a whether a team won the championship) showed that none of the leagues were statistically different from the MLB, while the fourth model (which looked at a team's valuation rank) suggested that all three of the other leagues were different than the MLB.

[31] As previously mentioned, the discussion about *Playoffs* and *Valuation Rank* begins with Appendix Figure A12.
[32] For example, if the interaction term *Payroll Z-Score:NBA* has a positive coefficient, it means that the impact is greater in the NBA compared to the MLB. If the coefficient is negative, it suggests that the relationship is weaker.

Table 11 – *Summary of Combined Regressions (MLB vs. NBA vs. NHL vs. NFL)*

	Response Variable			
	(1) Win Z-Score	**(2)** Playoffs	**(3)** Championship	**(4)** Valuation Rank
Payroll Z-Score	0.334*** (0.055)	0.130*** (0.028)	0.013 (0.011)	-4.119*** (0.302)
Payroll Z-Score:NBA	0.011 (0.069)	-0.013 (0.035)	0.011 (0.014)	2.260*** (0.387)
Payroll Z-Score:NHL	0.044 (0.072)	0.039 (0.037)	0.008 (0.014)	2.043*** (0.400)
Payroll Z-Score:NFL	-0.183** (0.065)	-0.076* (0.033)	-0.010 (0.013)	3.902*** (0.359)
R^2	0.255	0.286	0.105	0.708
Observations	2,489	2,489	2,489	2,489

Note. Models 2 and 3 use a pseudo R^2 calculation. *** p-value <0.001, ** p-value <0.01, * p-value <0.05.

While we could continue to discuss the results in Table 11, further refinements in the model seem warranted. Specifically, the findings suggest that the NBA and NHL are generally similar to the MLB, while the NFL typically diverged. Thus, we can group the three similar leagues together and directly compare the NFL, providing more pronounced insights into the differences between the leagues. Consequently, I ran the following regressions:

$$ResponseVariable_{it} = \beta_1 PayrollZScore_{it} + \beta_2 PayrollZScore_{it} * NFL + FE_i + \varepsilon_{it} \quad (17)$$

where *NFL* is an indicator variable that only takes the value "1" for teams in the NFL. In Table 12, a clearer picture emerges. Across all metrics, the impact of increased payroll is less significant in the NFL. We can see this in Table 12, since the coefficient for the NFL in all four models is statistically significant and has an opposite sign compared to the other three leagues (examine coefficients for *Payroll Z-Score* versus *Payroll Z-Score:NFL*). This means that while there is a positive association between payroll z-score and the four response variables in the MLB, NBA, and NHL, the relationship has a smaller magnitude in the NFL. In other words, higher payrolls in the NFL do not increase a team's regular season winning percentage, odds of making the playoffs, odds of winning the title, and valuation rank as significantly in comparison to the other three leagues. Simply put, money appears to have a statistically weaker impact in the NFL.

Table 12 – *Summary of Combined Regressions (MLB / NBA / NHL vs. NFL)*

	Response Variable			
	(1) Win Z-Score	**(2) Playoffs**	**(3) Championship**	**(4) Valuation Rank**
Payroll Z-Score	0.353*** (0.027)	0.138*** (0.014)	0.020*** (0.005)	-2.516*** (0.155)
Payroll Z-Score:NFL	-0.202*** (0.044)	-0.084*** (0.023)	-0.017** (0.008)	2.299*** (0.249)
R^2	0.255	0.285	0.105	0.703
Observations	2,489	2,489	2,489	2,489

Note. Models 2 and 3 use a pseudo R^2 calculation. *** p-value <0.001, ** p-value <0.01, * p-value <0.05.

6 Conclusion

Operating as multi-billion dollar entities, professional sports teams continually face meaningful decisions on how they want to spend their money. Significant evidence has shown that there is a relationship between a team's payroll and their performance. Ultimately, where they come out on that decision may depend on whether organizations prioritize winning on the field or maximizing financial profits and should vary for each sport based on the strength of the various relationships examined in this paper.

At first glance, the results appear somewhat correlated to the restrictiveness of each league's salary cap structure, where the impact of money on success was more significant in leagues that allow greater payroll flexibility (like the MLB and NBA). However, the more comprehensive concept of competitive balance revealed a much stronger parallel with the findings. Specifically, more imbalance was correlated with a stronger association between team payroll and performance, while greater parity was linked to a decrease in the impact of money. In earlier sections, most methods of measuring competitive balance found that the NBA experienced the greatest inequity and the NFL displayed the most parity, with the MLB and NHL residing in between. Throughout the empirical analysis, the relationship between payroll and performance was typically stronger in the sports that had less balance. In fact, subsequent analysis revealed that the NFL, which had the highest competitive balance, showed the statistically weakest relationship across multiple metrics of success.

In the regular season, increased payroll expenditure was associated with an increase in win percentage. Across all four sports, there was a statistically significant relationship, with incremental payroll standard deviations associated with an increase between 2.3 and 5.4 percentage points. Given the close proximity of teams in league standings, this can make a meaningful impact on a team's position in the standings, often determining whether or not a club will qualify for the playoffs. After standardizing winning percentages to take into account structural differences between leagues, we saw that the impact of additional payroll spending was less than half as impactful in the NFL versus the other three sports. This supports prior conclusions which revealed that competitive balance was greatest in the NFL, suggesting that organizations cannot buy their way into success. After using an advanced metric (Simple Rating System) that considers a team's margin of victory and strength of schedule, the explanatory power of payrolls increased for all sports. Thus, after reducing the role of luck and more accurately measuring a team's strength, we see that team payroll has an even more significant impact on their ability than previously thought. In sum, econometric analysis of all sports reveals that teams who spend more tend to perform greater in the regular season.

In the postseason, the relationship between payroll and championship attainment differs by sport. When controlling for team specific factors (by including fixed effects for each franchise), there was a statistically significant relationship only in the NBA and NHL, where each additional payroll standard deviation approximately doubled a team's odds of winning the title. Although each team's baseline chance of winning is approximately 3.3%, this effect compounds for each additional standard deviation, which makes a meaningful difference in how likely a team is to win the championship. After removing the team fixed effects and examining the static relationship between low spending versus high spending teams and their odds of winning a championship, the MLB joined the NBA and NHL in showing a positive relationship with team payroll. Yet again, money had essentially no impact on how likely a team was to win a title in the NFL, reinforcing its status as the league with the greatest parity.

Financially, increased payrolls were correlated with lower operating incomes. Across all four sports, each additional standard deviation in payroll was associated with a drop in operating profits between $2.2 million and $9.8 million. That means that additional investment in team payroll tended to increase revenue, but this rise did not fully offset the increase in player expenditures. When controlling for how well a team performed on the field during the regular season, we saw that additional payroll spending was still associated with lower profits in all sports, but teams in the MLB, NBA and NHL increased operating income as they won more games. This follows logical intuition, as better teams are generally more entertaining to watch, which drives up consumer demand. While there appears to be a disconnect between payroll, win percent, and operating income[33], it is critical to examine the relative magnitude of each relationship. After controlling for how much a team wins, the expected net effect of one additional payroll standard deviation is a drop in operating profits of -$3.1 million in the MLB, -$9.9 million in the NBA, -$2.2 million in the NHL, and -$6.5 million in the NFL. When additional payroll spending translates into a stronger team that has a greater winning percentage, teams tend to offset a larger portion of their expenses. However, if incremental payroll expenses fail to lead to a higher winning percentage, then teams directly incur the additional outlay but do not receive the benefit of having a winning club, resulting in a lower operating income. Since it can be hard for a franchise to predict how it will fare over the course of a season, their offseason decision making can be framed as such: do they want to prioritize winning (and hope that the resulting success will yield a higher operating income), or are they content to try to maximize profits by optimizing team payrolls? Overall, this paper provides evidence that on average, it is wiser to increase team payroll spending in the MLB, NBA and NHL because it can offset a larger portion of expenses if teams achieve better on-the-field performance. On the other hand, a larger dichotomy between winning and operating income exists in the NFL, where franchises' decisions should be based on their organizational preferences.

At the end of the day, organizations must make these choices based on their internal preferences. Understandably, some place a higher value on winning, while others favor financial profits. Empirical evidence shows that higher team payrolls tend to lead to greater success on the field (both in the regular season for all sports and in the postseason for the MLB, NBA, and NHL), while it also typically results in a lower operating income. Moving forward, teams would be wise to have a firm understanding of their organizational goals, and adjust their player personnel decisions to place themselves in a position to achieve their objectives.

[33] From earlier regressions, we found that higher payroll was associated with greater winning, higher win percentages were found to increase operating income (in the MLB, NBA, and NHL), and higher payrolls tended to decrease operating income. However, as previously explained, it is essential to pay attention to the magnitudes of the coefficients. After considering the full effects, all of the findings are consistent with one another.

While a lot of valuable insights can be gleaned from this paper, it is important to recognize a few notable limitations. First, this empirical analysis leverages fixed effects regression models to control for a variety of franchise factors (like coaching, management, location, etc.), but ideally one would be able to accurately measure all of these components to more precisely model the relationship. In future research, refinements could be made by developing a methodology to measure these factors, which may include finding proxy variables or devising a proprietary composite index. Next, subsequent analysis could expand upon the various metrics of success measured in order to understand how payroll is associated with an assortment of other outcomes such as division ranking, playoff victories, or team valuations, all of which would provide a broader perspective on the relationship between payroll and performance. However, the most important and significant limitation is a direct byproduct of the scope. Namely, this analysis focuses on payroll spending at the team level, which does not allow us to see into any potential relationships at the player level. In other words, this research has analyzed payroll spending based differences in total spending between teams, but there are likely similarly valuable conclusions that could be made by understanding how the distribution of spending within a team impacts the relationship. For instance, subsequent experiments may want to parse spending by certain positions (i.e. "How much money did a football team spend on their quarterback?") or by role on team (i.e. "How much did a team spend on offensive players compared to defensive players?"), which may find that not all spending equally translates into success. Not only could this proposed research complement and support the findings provided in this paper, but it could also offer valuable insights into how teams can most effectively spend money to achieve their organizational goals.

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8 Data Sources

Payroll and Financial Figures:

Fort, R. (2016). Rodney Fort's Sports Business Data. Retrieved March 1, 2017, from https://umich.app.box.com/s/ 41707f0b2619c0107

Team Performance Statistics:

http://www.baseball-reference.com

http://www.basketball-reference.com

http://www.hockey-reference.com

http://www.pro-football-reference.com

9 Appendix

Table A1 – *Key Facts and Taxonomy*

	(1) MLB	(2) NBA	(3) NHL	(4) NFL
"2015 Season"	2015	2015-16	2015-16	2015
Salary Cap	No	Yes	Yes	Yes
Luxury Tax	Yes	Yes	No	No
Average Score (Per Team)	4.2 runs	102.7 points	2.7 goals	22.8 points
Number of Teams	30	30	30	32
Number of Teams in Playoffs	10	16	16	12
Games per Season	162	81	81	16
Playoff Round Structure	Series[a]	Series	Series	Single Elimination
Number of Players on Roster	25	13	23	53

Note. All information is based off most recent season.
[a] Wild Card round is single elimination.

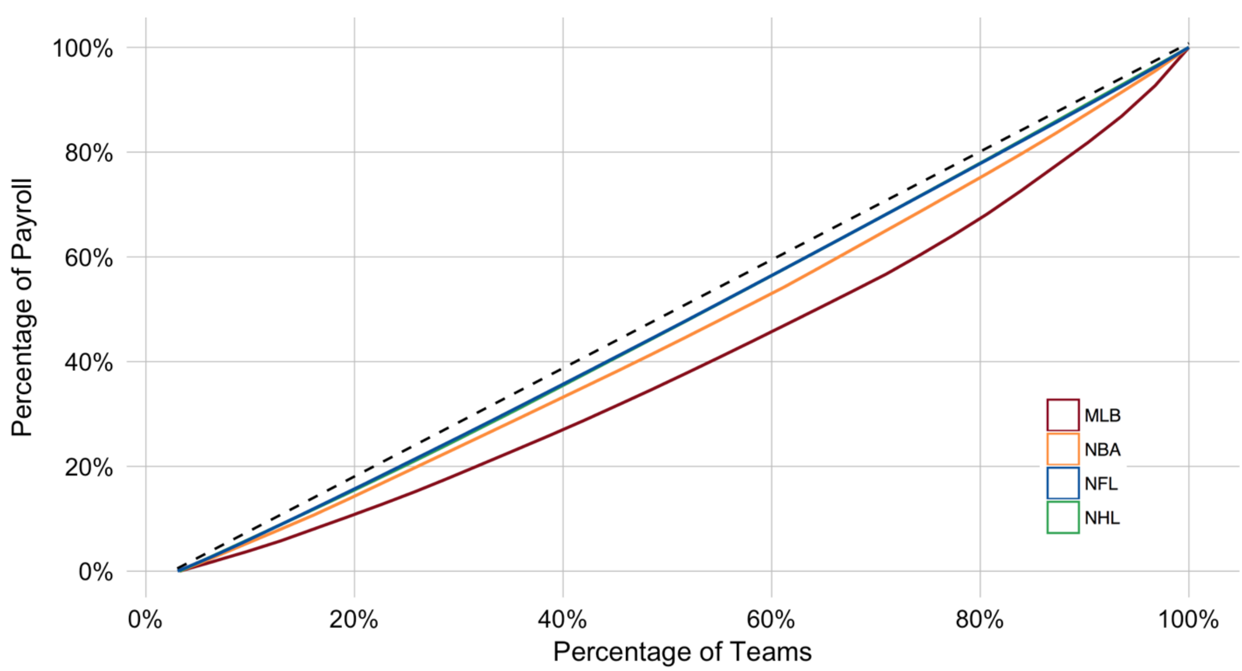

Figure A2. Lorenz curve for 2015 season team payrolls.

Figures A3-6: Team-Specific Regressions for Each League

Inspired by an article on *FiveThirtyEight* in which authors Noah Davis and Michael Lopez charted the relationship between spending and win percentage for every baseball season since 1985, the following four pages provide visualizations of the relationship between money and winning for each team across all four sports leagues. Each season is represented by one dot in the figure, and the colored line is a smoothed curve fit through the points. The gray line is an aggregation of all teams across the entire league, which shows a pattern that more money generally means more wins. When evaluating how effectively a team spent their money, it is important to look for several things. Teams that are located above the gray line have outperformed league averages, while organizations below the gray line have underperformed. The top-left quadrant represents the best of both worlds (low-spending and high-performing), while the bottom right is highly undesirable (high-spending and low-performing). Teams with steeper slopes have been more effective at spending their money (i.e. additional dollars have translated into more wins), while teams with flatter lines have seen their spending have less of an impact on their overall regular season performance.

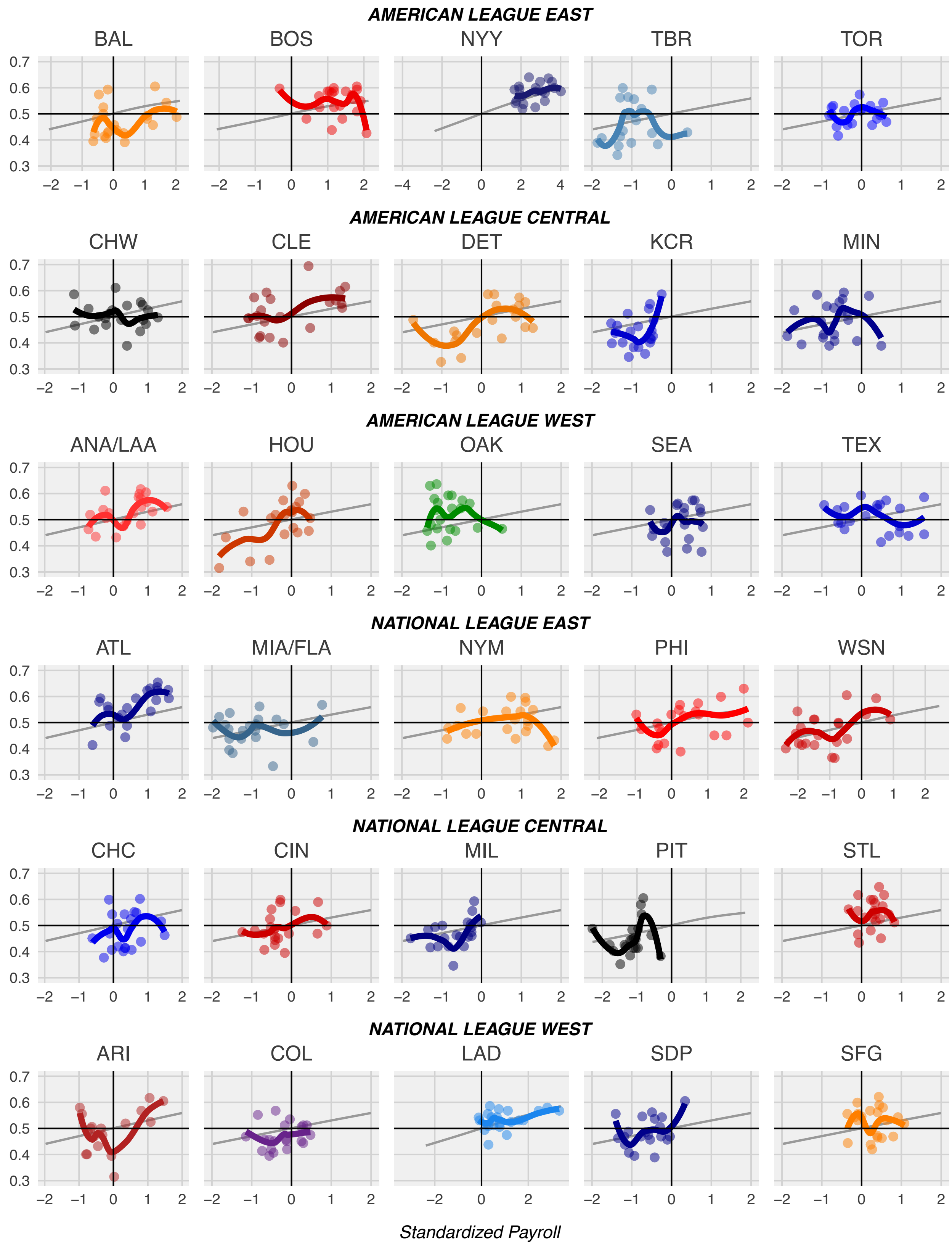

Figure A3. MLB – Payroll z-score versus winning percentage from 1995 to 2015.

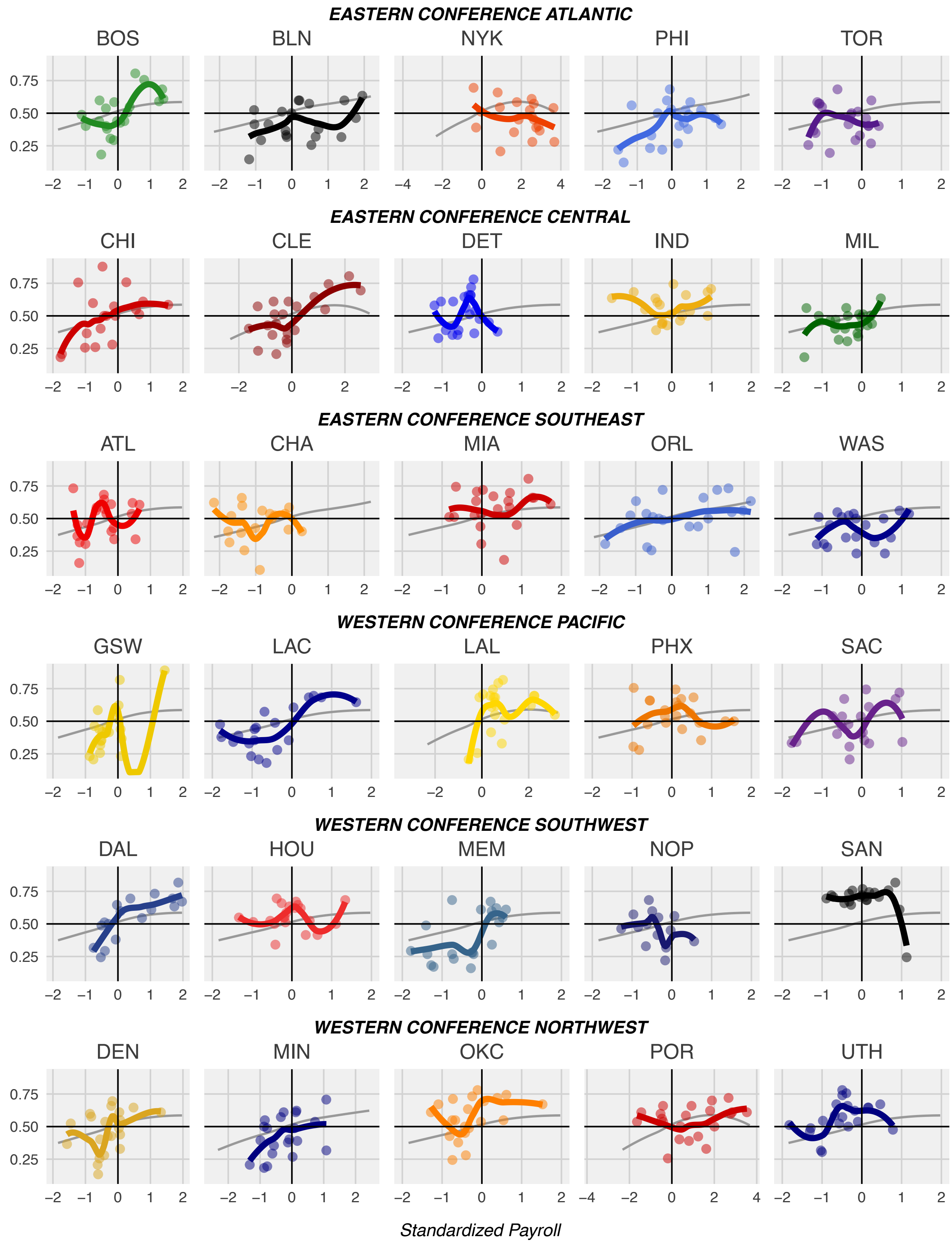

Figure A4. NBA – Payroll z-score versus winning percentage from 1995 to 2015.

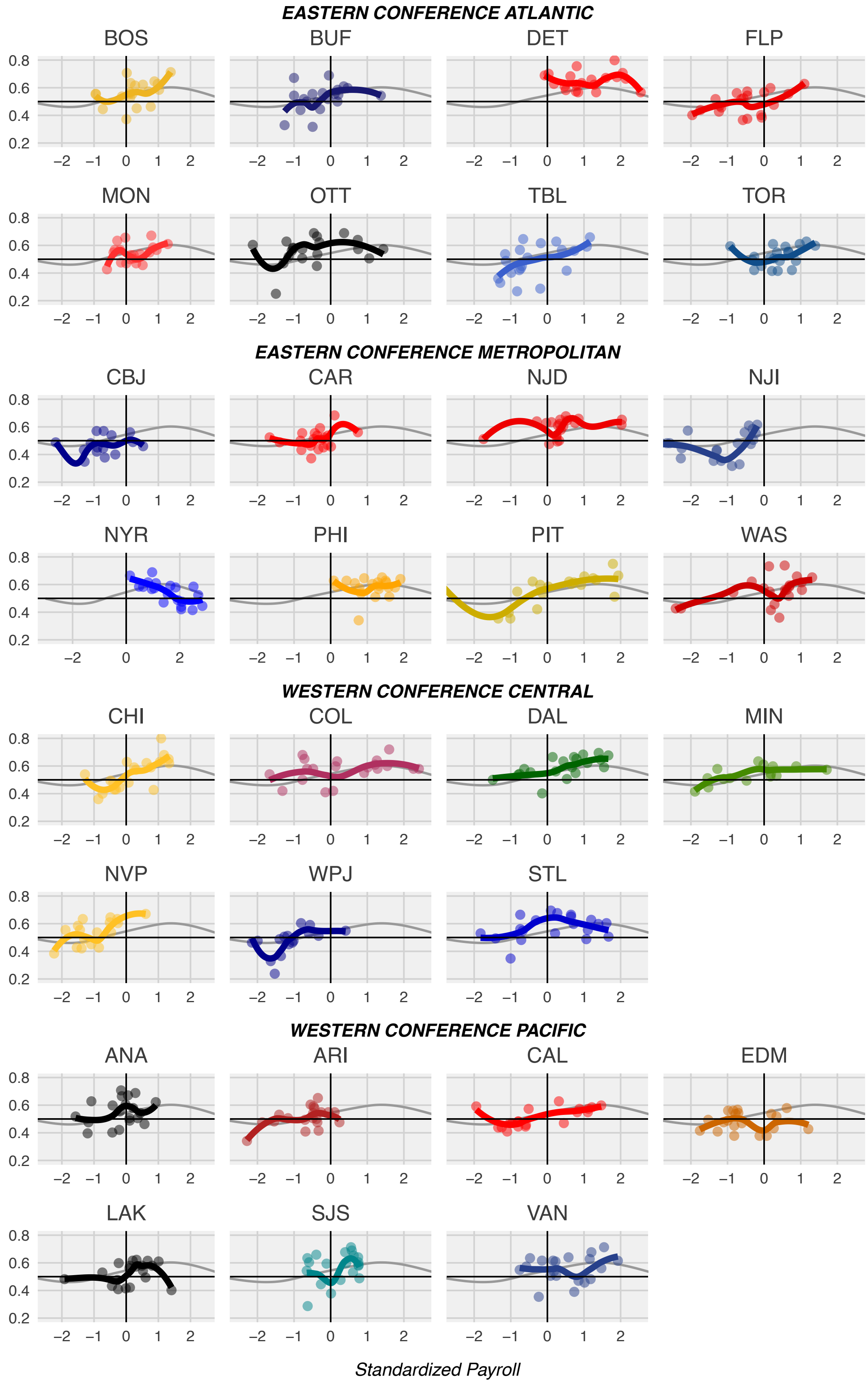

Figure A5. NHL – Payroll z-score versus points percentage from 1995 to 2015.

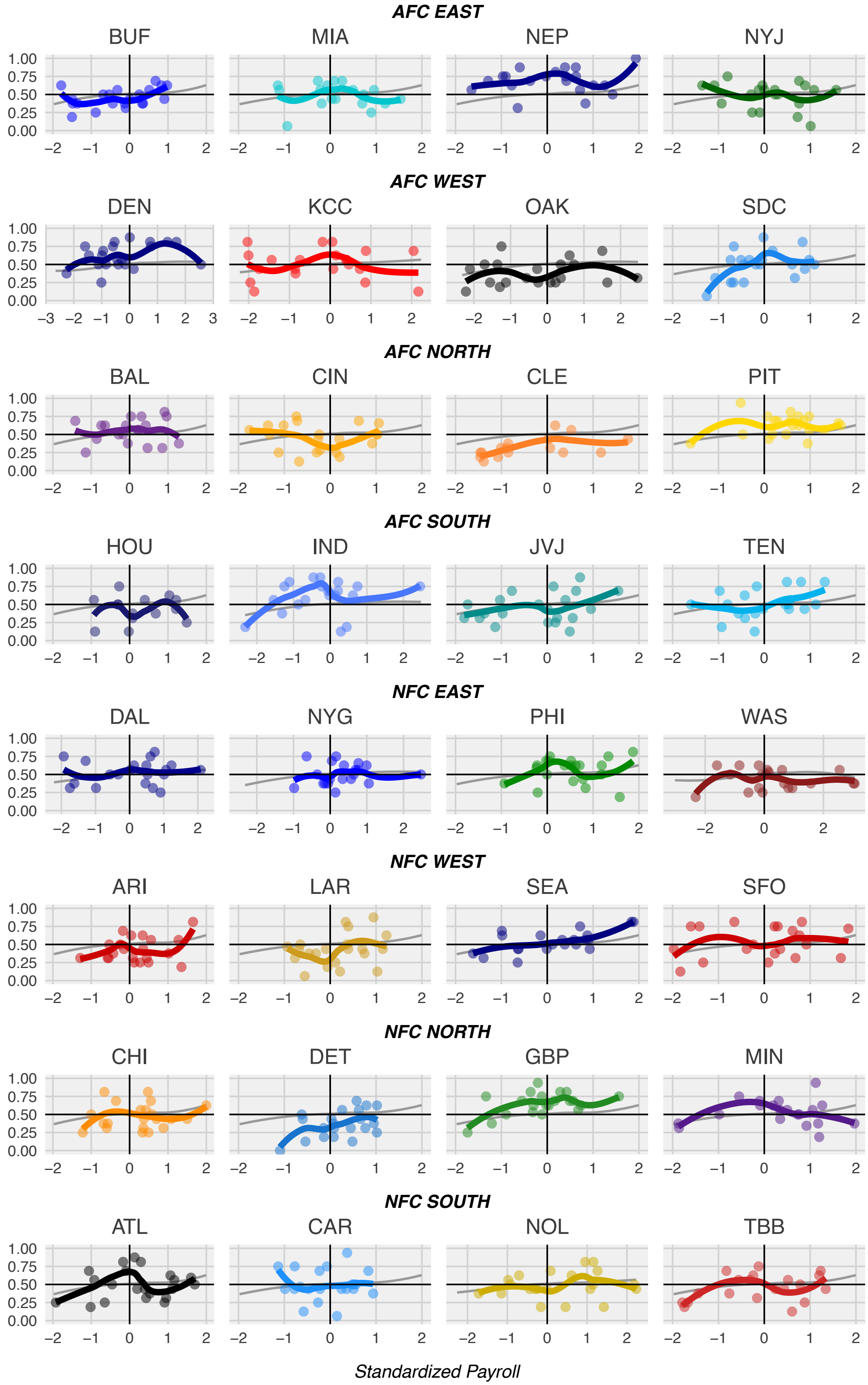

Figure A6. NFL – Payroll z-score versus winning percentage from 1995 to 2015.

Table A7 – *Payroll Standard Deviations*

Year	(1) MLB	(2) NBA	(3) NHL	(4) NFL
2015	$44,589,776	$10,615,728	$4,324,442	$17,222,048
2014	$42,756,039	$10,670,275	$4,622,295	$7,652,121
2013	$45,076,516	$12,010,768	$9,070,724	$6,084,828
2012	$36,139,806	$9,691,014	$10,079,475	$10,104,925
2011	$40,126,809	$10,192,499	$9,612,861	$10,230,947
2010	$37,593,320	$10,636,639	$10,861,097	$18,522,402
2009	$33,318,520	$9,372,279	$7,815,047	$12,752,208
2008	$37,295,809	$8,967,600	$7,968,239	$15,910,262
2007	$33,352,233	$10,714,495	$7,473,473	$8,849,803
2006	$31,728,835	$12,872,381	$4,620,275	$12,715,445
2005	$33,658,495	$17,259,718	$6,142,886	$9,908,739
2004	$32,271,186	$15,150,102	N/A[a]	$11,330,139
2003	$27,588,965	$12,591,231	$15,631,180	$8,316,003
2002	$24,316,234	$13,580,019	$16,592,968	$11,964,208
2001	$24,399,146	$11,015,386	$13,924,625	$12,561,560
2000	$21,560,263	$12,532,406	$11,461,928	$3,639,664
1999	$21,091,866	$10,661,962	$9,783,296	$4,084,847
1998	$14,860,714	$9,243,272	$7,226,774	$3,048,288
1997	$12,659,795	$9,031,079	$6,858,200	$2,349,938
1996	$9,879,287	$9,197,832	$5,205,078	$2,110,012
1995	$8,591,060	$6,385,984	$4,784,037	$1,986,953
Mean	$29,183,556	$11,066,318	$8,702,945	$9,111,683
Median	$32,271,186	$10,661,962	$7,891,643	$9,908,739

Note. [a] Due to a labor lockout dispute, the NHL cancelled the 2004 season.

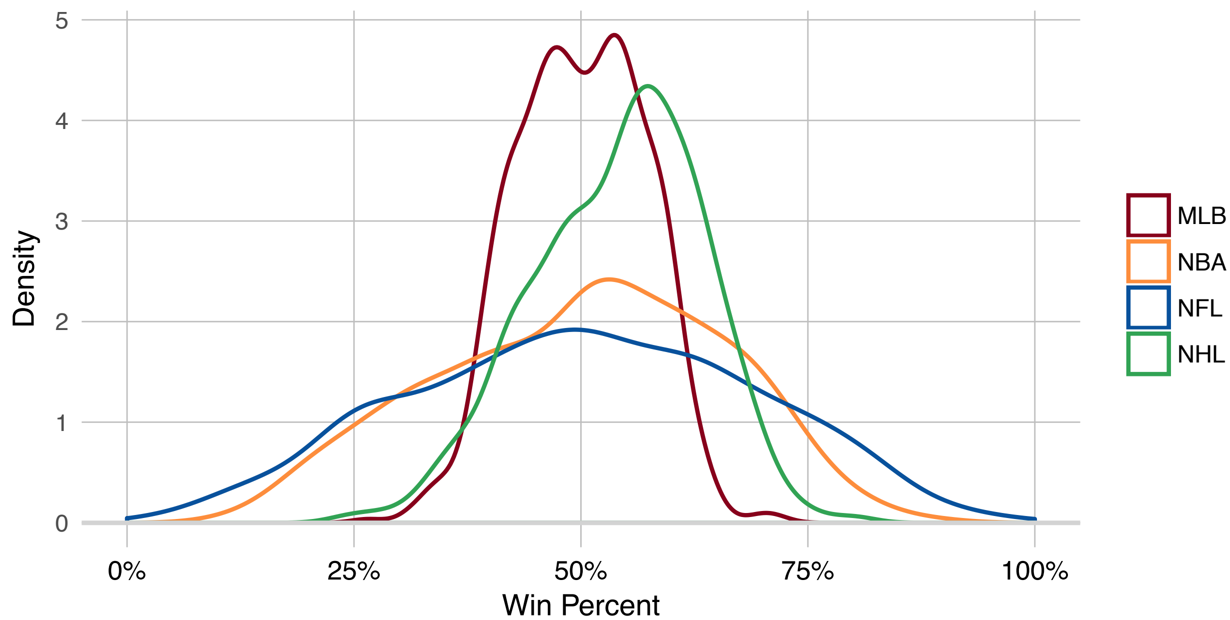

Figure A8. Distribution of winning percentages by league from 1995 to 2015.

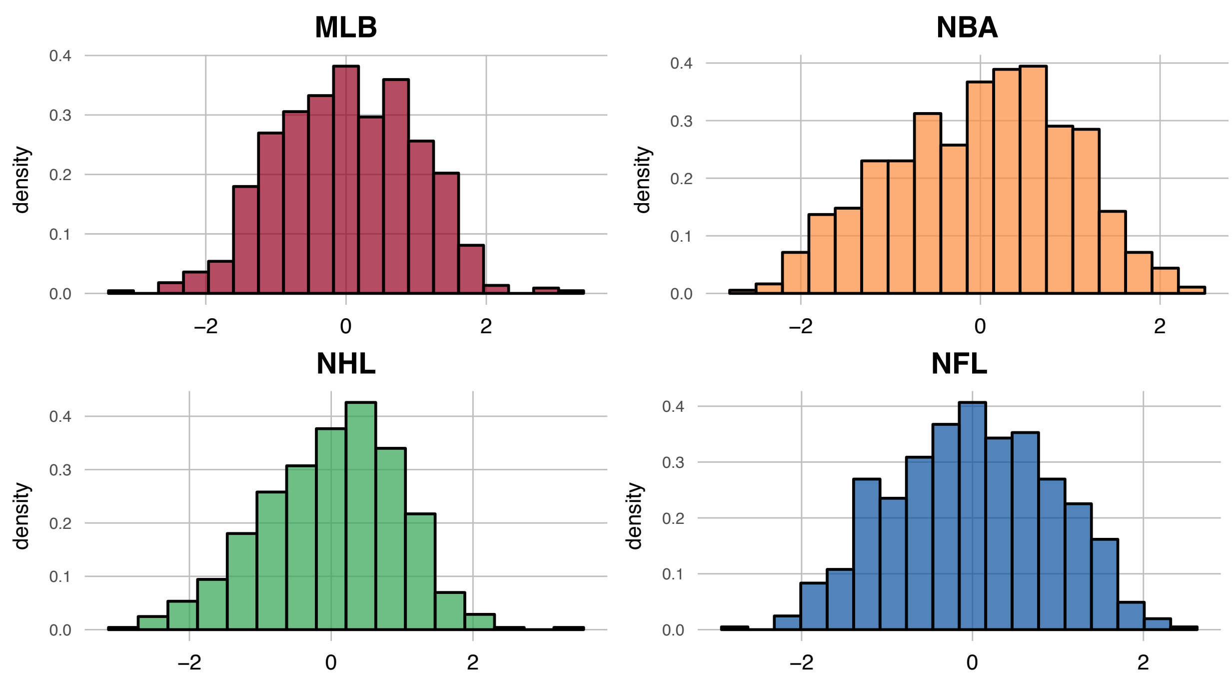

Figure A9. Histograms of win percent z-scores from 1995 to 2015.

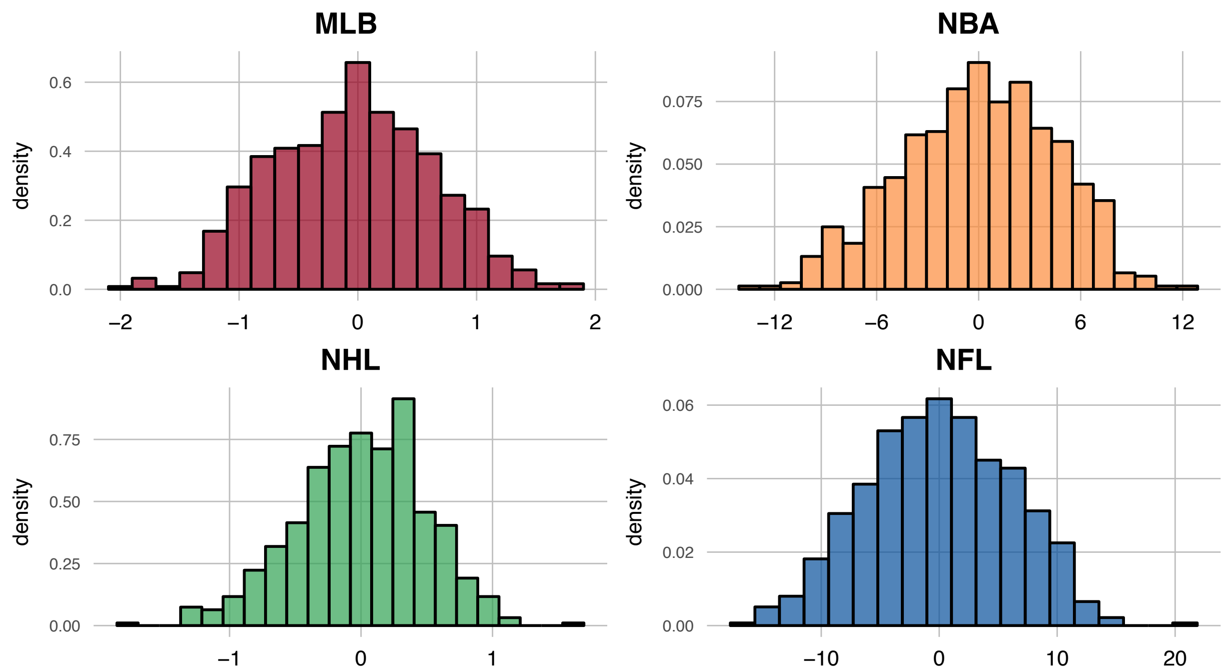

Figure A10. Histograms of SRS values from 1995 to 2015.

Table A11 – *Winning Percentage* = $\alpha + \beta_1 SRS_{it} + \varepsilon_{it}$

	(1) **MLB**	**(2)** **NBA**	**(3)** **NHL**	**(4)** **NFL**
Intercept	0.500***	0.500***	0.540***	0.500***
	(0.001)	(0.001)	(0.002)	(0.004)
SRS	0.093***	0.034***	0.175***	0.027***
	(0.002)	(0.000)	(0.003)	(0.001)
R^2	0.7824	0.941	0.846	0.770
Observations	624	621	583	661

Note. *** p-value <0.001, ** p-value <0.01, * p-value <0.05.

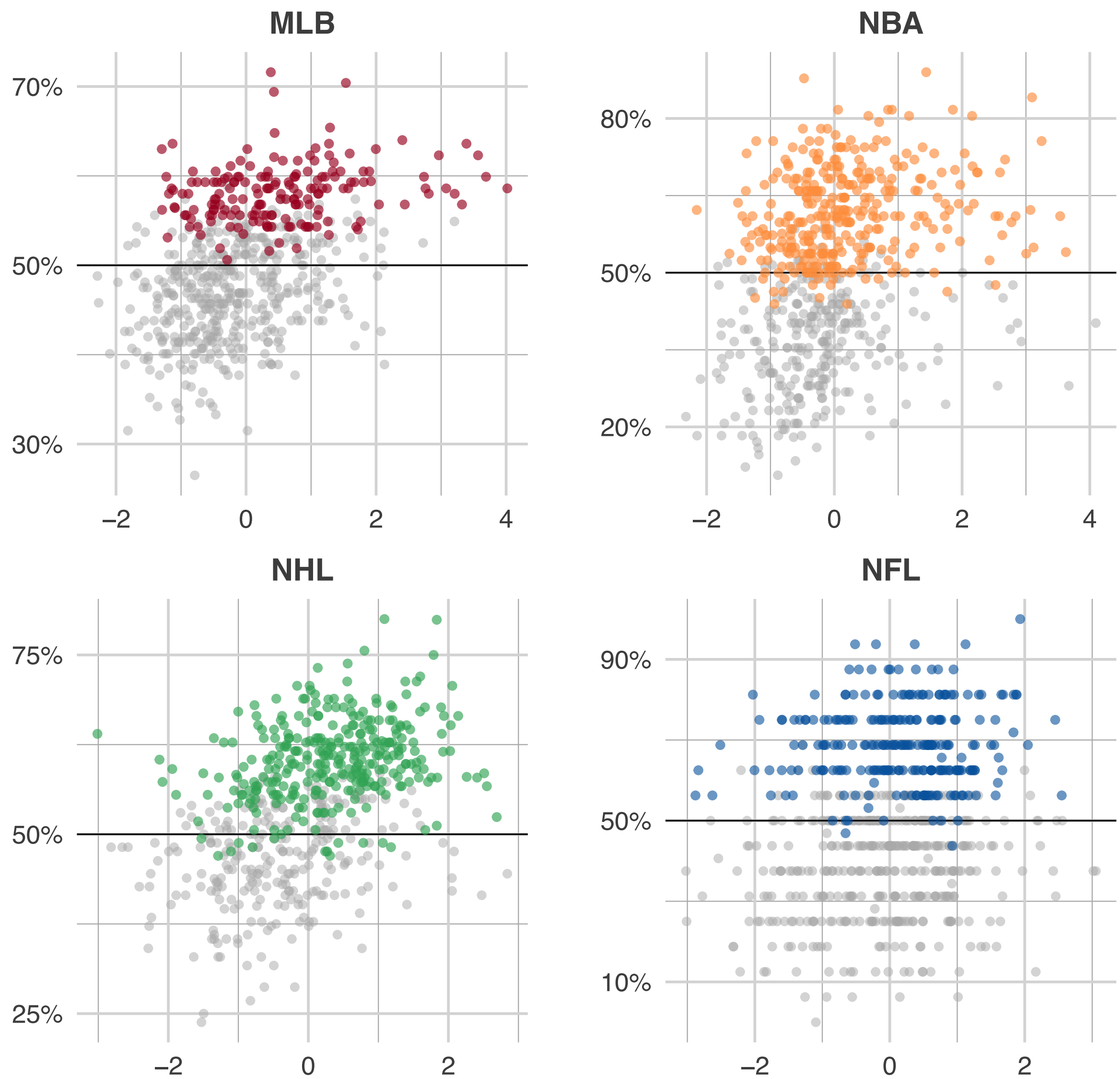

Figure A12. Payroll z-score versus made playoffs (colored dots denote team qualified).

Another important metric to determine a team's performance is whether they qualified for the playoffs. For some organizations, simply making the playoffs is a huge accomplishment that signifies a successful season. Since a team's presence in the playoffs is based on their regular season performance, this metric can be viewed as a hybrid between regular season and postseason success. In Figure A12, the horizontal axis shows payroll z-scores, the vertical axis represents regular season winning percentage, and the colored dots signify that a team made the playoffs (while gray dots indicate that they failed to qualify). However, to see differences in the likelihood that a team made the playoffs, we need to look at vertical bands and compare how frequently teams qualified for the postseason (i.e. compare the number of colored versus gray dots). For instance, we can look at the MLB's chart and see that for teams that had a payroll z-score between 3.0 and 4.0, seven of the eight teams made the playoffs. At the other end of the spectrum, all 26 teams that had payroll z-scores below -1.5 missed the playoffs. We see similar patterns in the NBA and NHL, implying that there is a relationship between a team's payroll and their odds of making the playoffs. And as has often been the case, the NFL appears to show a much weaker association, suggesting that money has less of an impact. To empirically quantify this relationship, I calculated the following logistic regression:

$$Playoffs_{it} = \beta_1 PayrollZScore_{it} + FE_i + \varepsilon_{it} \quad (18)$$

where $Playoffs_{it}$ is an indicator variable that takes the value "1" if the team made the playoffs and is "0" otherwise. Table A13 provides a summary of the results, which show that higher payrolls are associated with increased odds of making the playoffs across all four leagues. Additionally, the magnitudes of the coefficients all are roughly consistent with Figure A12. Specifically, the impact of payroll is most significant in the MLB and NHL, where incremental payroll standard deviations more than double a team's odds of making the playoffs. The NBA had a marginally weaker relationship, where each standard deviation increased a team's likelihood by a factor of roughly 1.75. Lastly, the NFL displayed the weakest positive association, where each incremental standard deviation only made a team 1.3 times more likely to make the playoffs. As anticipated, the results here closely mirror previous findings (especially Equation 10, which examined win percent z-scores), where we saw that higher spending was associated with improved regular season performance across all leagues, but was least significant in the NFL. Given the substantial overlap in what the metrics measure, it would be mildly redundant to include this regression on whether a team qualified for the playoffs, since it is a direct function of how well a team performed in the regular season. For this reason, even though making the playoffs is a major achievement for many teams, I have chosen to focus on the other metrics (raw winning percentages, standardized winning percentages, and SRS values) in the body of this paper.

Table A13 – *Logistic Regression: Playoffs = β_1PayrollZScore$_{it}$ + Team Fixed Effects*

	(1) MLB	(2) NBA	(3) NHL	(4) NFL
Payroll Z-Score	0.771***	0.554***	0.884***	0.270**
	(0.160)	(0.112)	(0.134)	(0.091)
Payroll Odds-Ratio	2.163***	1.740***	2.420***	1.310**
Pseudo R^2	0.582	0.262	0.780	0.191
Observations	624	621	583	661

Note. *** p-value <0.001, ** p-value <0.01, * p-value <0.05.

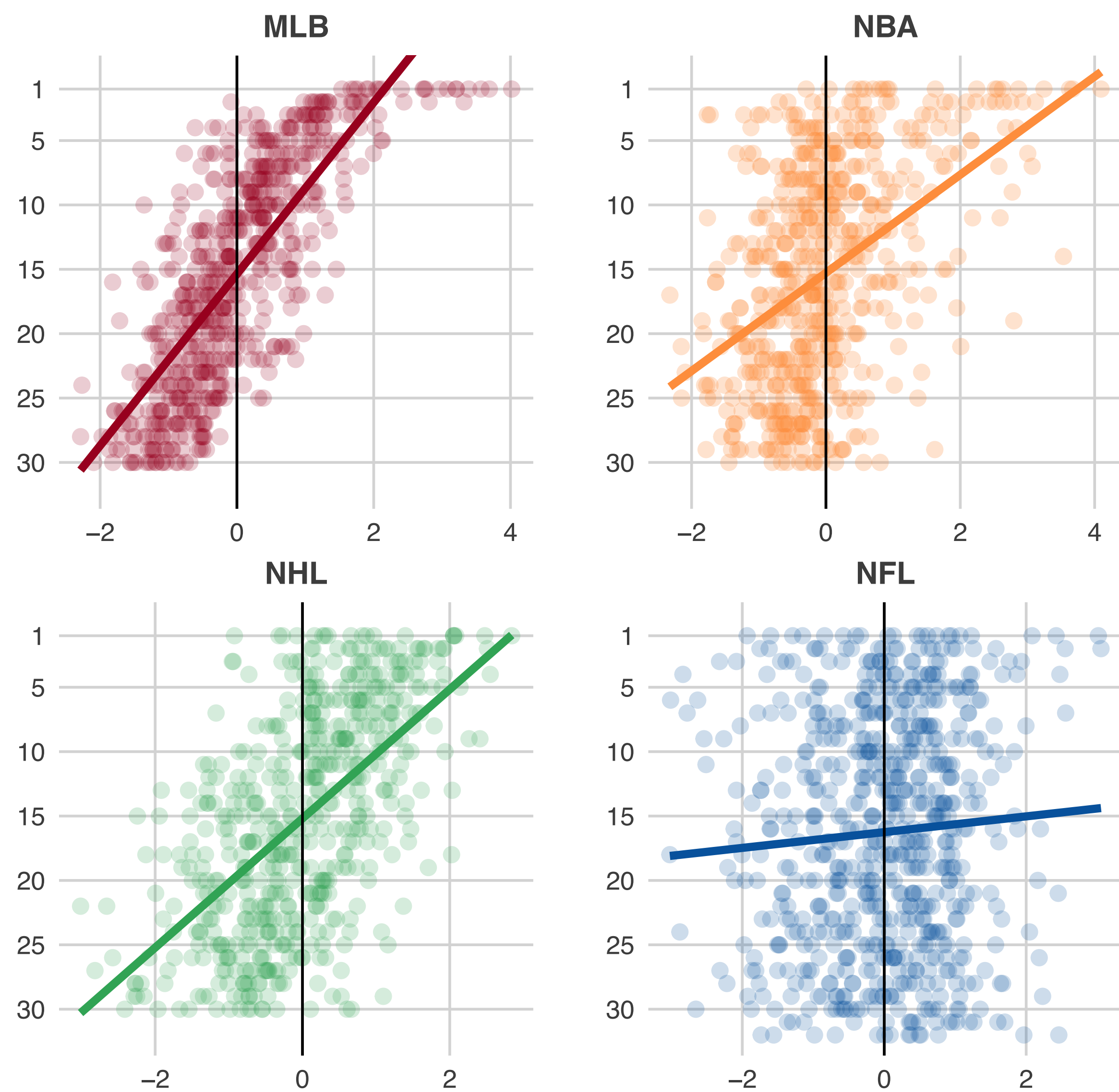

Figure A14. Payroll z-score versus team valuation rank.

Although this paper decided to focus on examining the relationship between team payroll and operating income (for reasons previously explained), we can also examine the link between payroll and franchise valuation. In Figure A14, I have plotted the payroll z-score from each team-season on the x-axis and their corresponding valuation rank on the y-axis (provided by Forbes' annual estimates). In the MLB, NBA, and NHL, there appears to be a positive relationship, where higher spending teams also generally had higher valuations. The NFL revealed a cloudier picture, where it was hard to discern any clear relationship. To determine the empirical relationship, I ran the following regression:

$$ValuationRank_{it} = \beta_1 PayrollZScore_{it} + FE_i + \varepsilon_{it} \qquad (19)$$

where $ValuationRank_{it}$ represents a team's rank in estimated valuation (smaller values refer to higher valued teams, while larger values represent the lower valued teams). In Table A16, we see that the relationship is statistically significant in the MLB, NBA, and NHL, where higher spending was associated with a higher ranking in franchise valuation. In contrast with operating income, this result suggest that larger payrolls were associated with a more favorable financial outcome.

Table A15 – *Valuation Rank = β_1*PayrollZScore$_{it}$ + Team Fixed Effects*

	(1) **MLB**	**(2)** **NBA**	**(3)** **NHL**	**(4)** **NFL**
Payroll Z-Score	-4.026***	-1.859***	-2.076***	-0.218
	(0.251)	(0.242)	(0.239)	(0.235)
R^2	0.796	0.698	0.747	0.606
Observations	624	621	583	661

Note. *** p-value <0.001, ** p-value <0.01, * p-value <0.05.

However, it is imperative to note that the results presented in Table A15 likely suffer from critical endogeneity issues. Namely, unaccounted variables appear to be critical omissions. To better discern the appropriateness of the regression, I calculated the following:

$$ValuationRank_{it} = \beta_1 PayrollZScore_{it} + \varepsilon_{it} \qquad (20)$$

where everything is the same as Equation 19, except that team fixed effects have been removed. Table A16 provides a summary of the regression results. Most critically, the r-squared values have all dropped significantly, which suggests that a lot of the explanatory power was explained simply by knowing which franchise each data point came from. Therefore, in addition to previously discussed motives for focusing on the relationship between team payroll and operating income, we now see additional hesitations to examining the association with valuation. Despite the limitations, we can still assess the regression results, albeit with some reservations. Larger payrolls were associated with a higher team valuation rank in the MLB, NBA, and NHL, while the NFL's results deviated and did not reveal an economically significant relationship.

Table A16 – *Valuation Rank* = $\alpha + \beta_1 * PayrollZScore_{it}$

	(1) **MLB**	**(2)** **NBA**	**(3)** **NHL**	**(4)** **NFL**
Intercept	15.356***	15.273***	15.190***	16.250***
	(0.217)	(0.314)	(0.292)	(0.354)
Payroll Z-Score	-6.664***	-3.811***	-5.014***	-0.611*
	(0.217)	(0.312)	(0.292)	(0.352)
R^2	0.602	0.200	0.347	0.005
Observations	624	621	583	661

Note. *** p-value <0.001, ** p-value <0.01, * p-value <0.05.